5-A-29

Instruction Manual

INSTRUMENT SPECIALISTS, INC.
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ADDENDUM - MODEL

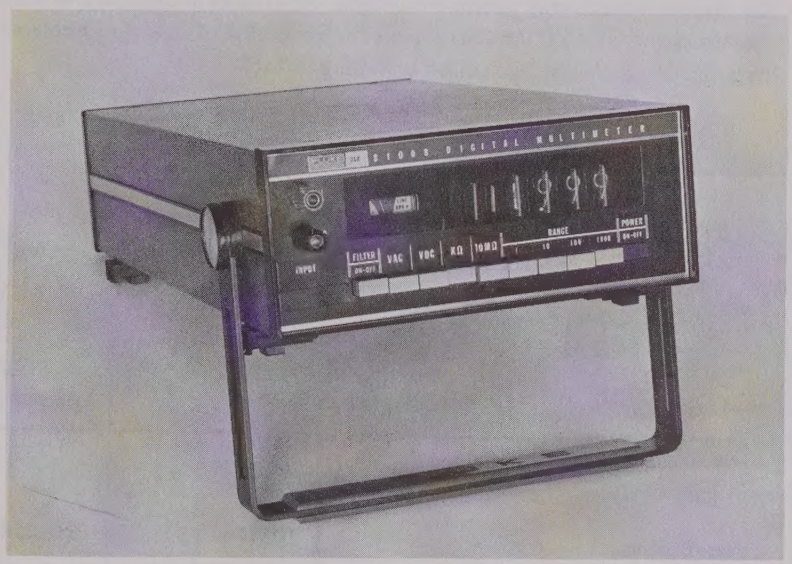
8100B

DIGITAL MULTIMETER

FLUKE®

JOHN FLUKE mfg. co., inc.
SEATTLE, WASHINGTON

JOHN FLUKE MFG. CO., INC.
P. O. Box 7428
Seattle, Washington 98133



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DIGITAL MULTIMETER

AUGUST 1972

INTRODUCTION

The Model 8100B is a Model 8100A without the GUARD terminal and enclosed in different styled plastic covers. Except for connecting the inner guard to INPUT LO, the instruments are, electrically, identical. Mechanical differences include the covers, carrying handle, removal of GUARD terminal (J3), and relocation of the 115/230 volt slide switch to the rear panel for direct access

MANUAL CHANGES

The manual requires only minimum changes. References in the text and schematic concerning the GUARD terminal should be disregarded. The List of Replaceable Parts, Section 5, should be changed according to Table 1.

Table 1. CHANGES—LIST OF REPLACEABLE PARTS

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
J3		DELETE						
3		Cover, Bottom	303164	89536	303164	1		
4		Cover, Top	291989	89536	291989	1		
5		Handle, Carrying						
		Frame	310045	89536	310045	1		
		Grip	284836	89536	284836	2		
		Knob, male half	309047	89536	309047	2		
		Knob, female half	309054	89536	309054	2		

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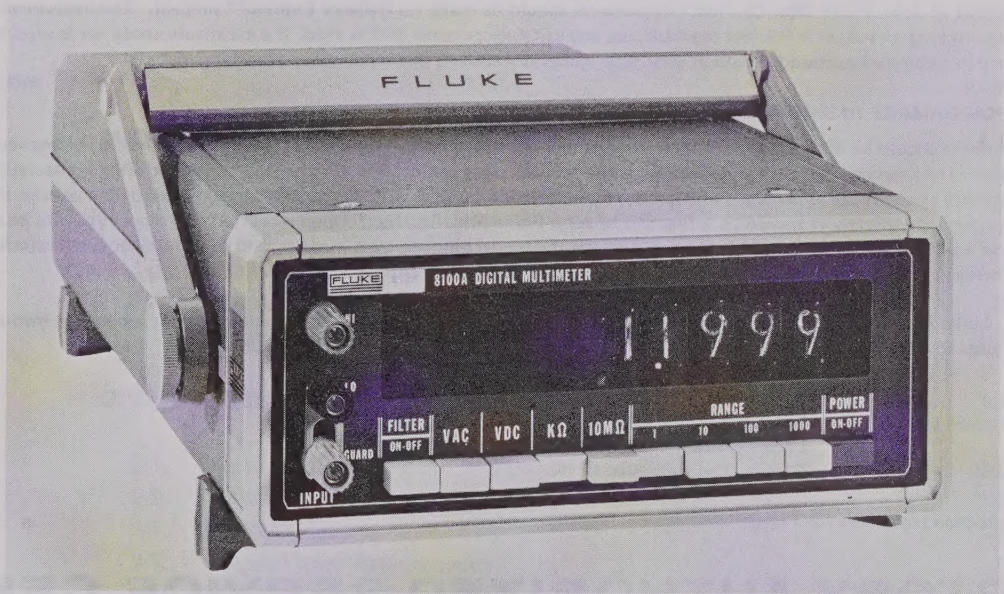

MODEL

8100A

DIGITAL MULTIMETER

Rev. 1 7/1/71 Rev. 2 10/21/71 Rev. 3 11/19/71
Rev. 4 2/11/72

OCTOBER, 1969

WARRANTY

The JOHN FLUKE MFG. CO., INC.* warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken:

1. Notify the John Fluke Mfg. Co., Inc.,* giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forewarded to you.

2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SHIPPING

All shipments of John Fluke Mfg. Co., Inc.* instruments should be made via **Railway Express**** prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to John Fluke Mfg. Co., Inc.* Upon receipt of this report you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

The John Fluke Mfg. Co., Inc.* will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to: JOHN FLUKE MFG. CO., INC., P.O. BOX 7428, SEATTLE, WASHINGTON 98133.*

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Section 1

Introduction & Specifications

1-1. INTRODUCTION

1-2. The Fluke Model 8100A Digital Multimeter is a versatile, accurate instrument, which measures ac and dc voltage in four ranges to 1000 volts and ohms in five ranges to 10 megohms. Standard features of the Model 8100A include full guarding, a switched two-pole active filter, autopolarity, pushbutton function and range selection, and full four-digit readout plus "1" for overranging. Fluke's unique Recirculating-Remainder (R^2)A/D conversion technique enables multiple use of discrete and integrated components for the various operating modes, thereby reducing parts count and power consumption while increasing reliability.

1-3. Accessories and options for the Model 8100A include the rechargeable battery pack (Option -01), High Frequency Probe, High Voltage Probe, Switched AC/DC Current Shunts, Front Panel Dust Cover, and Rack Mount Kit. A detailed description of the battery option and each accessory is given in Section VI of the manual.

1-4. ELECTRICAL SPECIFICATIONS

DC Volts

RANGE
±1, ±10, ±100, ±1000 volts dc with 20% overrange on all ranges.

RESOLUTION
0.01% of range (100 uv on 1v range maximum).

ACCURACY
30 days, 20°C to 30°C: ±(0.02% of input +0.01% of range).
90 days, 15°C to 35°C: ±(0.05% of input +0.01% of range).

DC INPUT RESISTANCE
Constant 10 megohms on all ranges.

FILTER
Switch selected two-pole, linear phase active filter.

RESPONSE TIME TO RATED ACCURACY
0.5 seconds with filter out.
1.5 seconds with filter in.

REJECTION

	INTERFERENCE FREQUENCY				
		60 Hz		50 Hz	
	DC	FILTER IN	FILTER OUT	FILTER IN	FILTER OUT
CMRR (1K in Low Lead)	120 db	120 db	100 db	120 db	100 db
NMRR	– – –	60 db	20 db	47 db	9 db

NOTE: CMRR = Common Mode Rejection Ratio
NMRR = Normal Mode Rejection Ratio
CMRR approaches infinity when instrument is battery operated.

POLARITY
Automatic, instantaneous selection and display.

OVERLOAD
±1200 vdc or ±1700v peak ac can be applied indefinitely on any range without damage.

AC Volts

RANGE
1, 10, 100, 1000 volts ac with 20% overrange on all ranges.

RESOLUTION
0.01% of range (100 uv on 1v range is maximum).

ACCURACY
90 days, 15°C to 35°C:

MIDBAND 50 Hz to 10 kHz	EXTENDED 30 to 50 Hz and 10 to 20 kHz
±(0.2% of input +0.05% or range)	±(0.5% of input + 0.1% of range)

INPUT IMPEDANCE
1 megohm shunted by <30 pf.

RESPONSE TIME TO RATED ACCURACY
3 seconds

MAXIMUM DC NORMAL MODE VOLTAGE
±1200 vdc.

NOTE: The sum of DC Normal Mode Voltage and peak ac voltage must not exceed ±1700v.

OVERLOAD
±1200 vdc or ±1700v peak ac from 30 Hz to 20 kHz can be applied indefinitely on any range without damage.

Resistance

RANGE
1k, 10k, 100k, 100k, and 10 MΩ with 20% overrange on all ranges.

RESOLUTION
0.01% or range (0.1 ohm on 1k range is maximum).

ACCURACY

	1k to 1000k	10M
30 days 20°C to 30°C:	±(0.05% of input +0.01% of range)	±(0.1% of input + 0.01% of range)
90 days, 15°C to 35°C:	±(0.1% of input + 0.02% or range) on all ranges	

CONFIGURATION
Two terminal, constant current.

VOLTAGE ACROSS INPUT
1.0v at full range.
1.2v at 20% overrange.
9v with open terminals.

POWER IN UNKNOWN R
⩽ 1 milliwatt in range and ⩽ 1.44 milliwatts at 20% overrange on the 1K range, decreasing by an order of magnitude per range to 100 nanowatts at 10 megohm.

RESPONSE TIME TO RATED ACCURACY

	1k to 1000k	10M
Filter Out	0.5 seconds	3.0 seconds
Filter In	2.0 seconds	10.0 seconds

OVERLOAD

1k Range	130 vrms may be applied indefinitely without damage.
10k to 10 MΩ	230 vrms may be applied indefinitely without damage.

MAXIMUM INPUTS

HI to LO	See OVERLOAD specifications by function.
LO to GUARD	100 vdc or peak ac.
GUARD to chassis	1200 vdc or 230v rms at 60 Hz.

POWER
8 watts from 115V/230V, ±10%, 50 to 500 Hz line with internal battery option –01. Eight hours continuous operation from the rechargeable nickel-cadmium batteries.

1-5. ENVIRONMENTAL SPECIFICATIONS

HUMIDITY RANGE
Meets all specifications to 80% relative humidity for temperatures ⩽ 35°C and 70% relative humidity for temperatures above 30°C to 50°C.

SHOCK AND VIBRATION
Meets requirements of MIL-T-21200 G and MIL-E-16400F.

STORAGE TEMPERATURE
–40°C to +75°C.
–40°C to +60°C for batteries.

Operating Temperature
0°C to +50°C.

Temperature Coefficient

FUNCTION	TEMPERATURE COEFFICIENT
DC Volts	±(0.0025% of reading + 0.001% of range)/°C
AC Volts	±(0.015% of reading + 0.005% of range)/°C
KΩ	±(0.0035% of reading + 0.0015% of range)/°C
10 MΩ	±(0.01% of reading + 0.002% of range)/°C

NOTE: Add temperature coefficient only outside of temperature limits noted in 30 and 90 day specifications.

1-6. MECHANICAL SPECIFICATIONS

Weight
8 pounds without batteries.
10 pounds with batteries.

Mounting
Tilt-down carrying handle detents into custom non-marring feet and serves as a tilt-up bail for bench use. The Model 8100A outline drawing is shown in Figure 1-1, with approximate overall dimensions.

1-7. GENERAL SPECIFICATIONS

Selection
Function and range selection is manual via mechanically interlocked pushbutton switches.

Display
Four decade neon in-line readout with polarity neon for dc volts and fifth digit for 20% overrange. Automatic decimal location.

Sample Rate
Three samples per second.

Accessories Available
High Frequency Probes
High Voltage Probes
Switched AC/DC Current Shunts
Front Panel Dust Cover
Rack Mount Kit

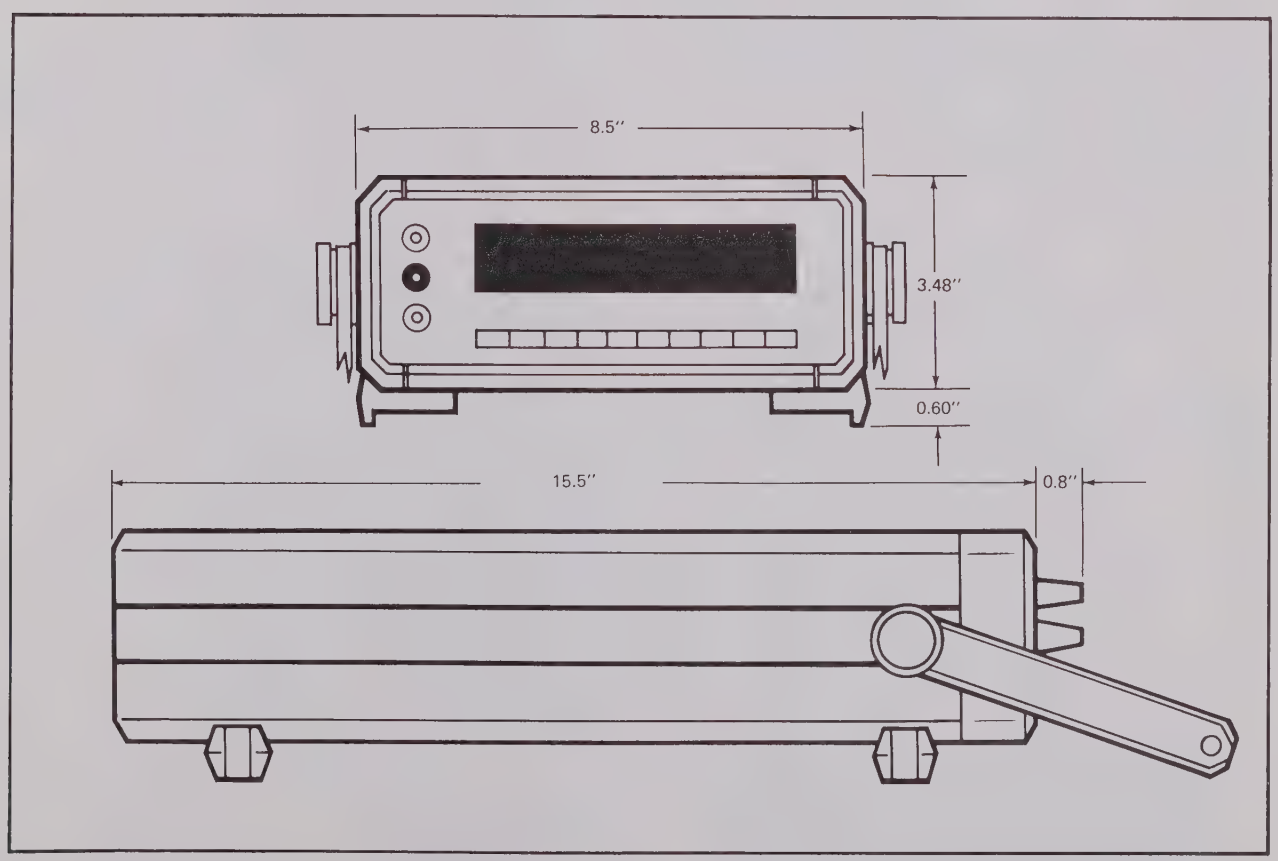


Figure 1-1. MODEL 8100A OUTLINE DRAWING

Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. This section contains operating instructions and applications information for the Model 8100A Digital Multimeter. Included in the instructions is a detailed description of the instrument controls, terminals, and indicators and an operational check, which verifies satisfactory operation of the instrument using only front panel controls. If any problem is encountered in operating the instrument, contact the nearest John Fluke Sales Representative or write directly to the John Fluke Manufacturing Company. Please include the instrument serial number when writing.

2-3. INSTALLATION

2-4. The Model 8100A is supplied with non-marring feet and tilt-down bail for bench or field use. Rack mounting kits for installation of one instrument or two instruments side-by-side in a standard 19 inch rack are available as accessories and are described in Section VI of the manual.

2-5. ACCESSORIES

2-6. The following Model 8100A accessories are available at additional cost. A detailed description of the accessories is given in Section VI of the manual.

High Frequency Probe
High Voltage Probes
Switched AC/DC Current Shunts
Front Panel Dust Cover
Rack Mount Kit

2-7. INPUT POWER REQUIREMENTS

2-8. The instrument operates on either 115 or 230 volt, 50 Hz to 500 Hz ac power or directly from the optional battery pack. Before applying ac power to the instrument, remove the bottom dust cover and note the position of the 115/230 volt slide switch at the rear of the instrument. If the switch does not indicate the desired operating voltage, proceed as follows:

a. Place the 115/230 volt switch in the position that corresponds to the desired operating voltage.

b. Ensure that the proper line fuse for the selected voltage is installed before operating the instrument. For 115 volt operation, the fuse should be 1/8 ampere slow-blow and for 230 volt operation, the fuse should be 1/16 ampere slow-blow.

c. Replace the bottom dust cover and connect the instrument to the line.

WARNING!

The round pin on the polarized three-prong plug connects the instrument case to power system ground. If a three-to-two-wire adapter is used or if the instrument is powered from batteries with the line cord disconnected, ensure that the instrument case is connected to a

high quality earth ground. This can be done by connecting a wire between the center pin on the rear panel ac connector and earth ground.

2-9. The optional battery pack supplies the operating power for the instrument whenever the ac power cord is disconnected from the ac line. The battery is charged by connecting the instrument to the ac line and turning the instrument on. The front panel meter monitors the charge on the battery during battery operation and during line operating it indicates LINE OPR (full scale). A detailed description of the battery option is provided in Section VI of the manual.

2-10. OPERATING FEATURES

2-11. The name and function of the front and rear panel controls, terminals, and indicators are shown in Figure 2-1.

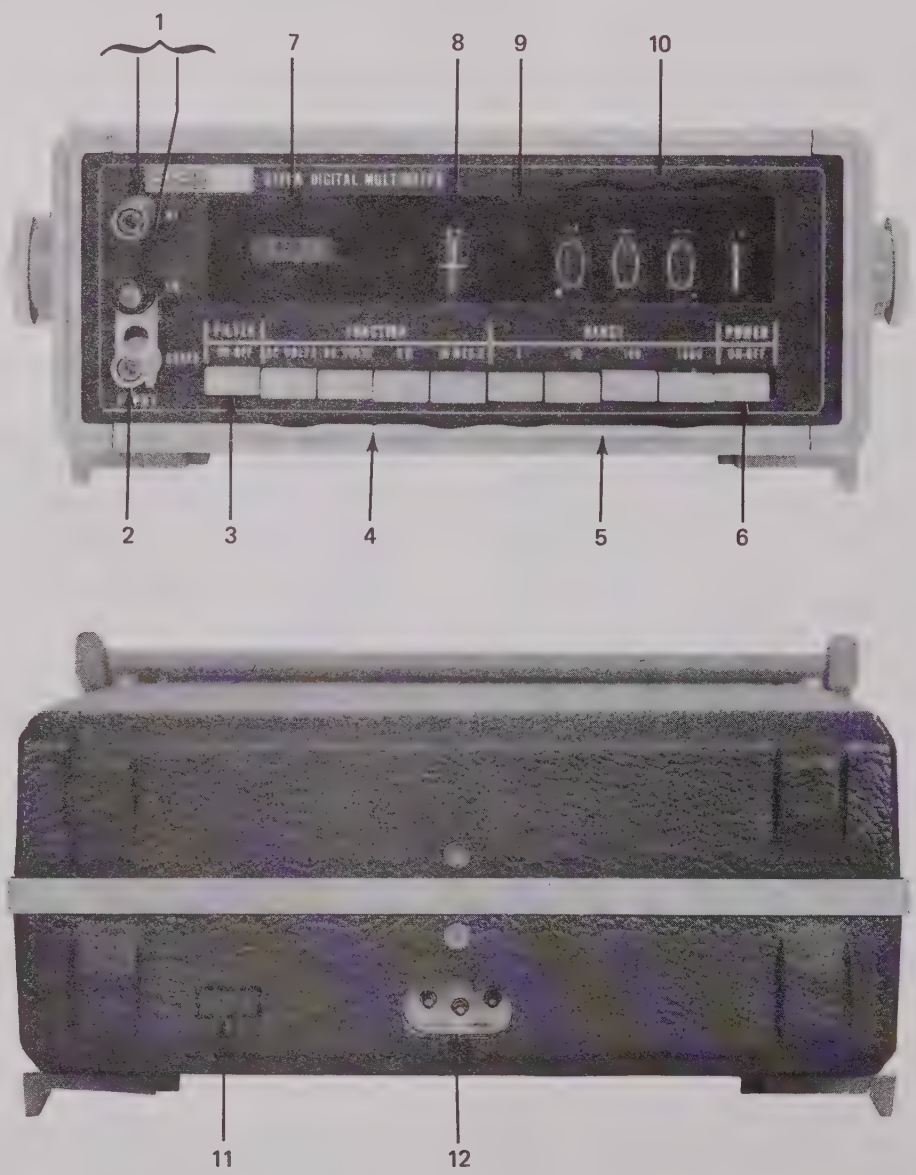


Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (Sheet 1 of 2)

REF. NO.	NAME	FUNCTION
1	INPUT Terminals	Input connections for dc voltage, ac voltage, and resistance measurement.
2	GUARD Terminal	Connects to internal guard chassis. When properly connected externally, provides increased ac and dc common mode rejection. GUARD terminal may be connected directly to the LO terminal or disconnected from the LO terminal and driven by a separate GUARD potential.
3	FILTER ON–OFF Switch	Push on-push off switch selects the two-pole active input filter when depressed (ON) and reduces the amount of filtering when released (OFF).
4	Function Switches	Four pushbutton switches select the desired operating mode: VAC (ac voltage mode), VDC (dc voltage mode). KΩ (Kilohm mode), and 10 MΩ (10 megohm mode).
5	RANGE Switches	Four pushbutton switches select the full-scale input range for voltage or resistance measurement. Ranges of 1, 10, 100, and 1000 are provided for each function except 10 MΩ, which is fixed independent of the RANGE switch .
6	POWER Switch	Push ON - push OFF switch controls input power to the instrument. When depressed, instrument is ON; when released, instrument is OFF.
7	Battery Meter	Indicates charge condition of battery when the battery option is installed and the instrument is operating from the batteries. When the instrument is on the line and the batteries are charging, the meter indicates LINE OPR (full scale).
8	Polarity Indicator	Neon indicator tube indicates "+" when positive voltages are applied to the instrument and "–" when negative voltages are applied to the instrument.
9	Overrange Indicator	Neon indicator displays "1" for full-scale readout and 20% overrange on each range. When a maximum overrange input is applied to the instrument, in any operating mode, the readout will be 11999, with the decimal point positioned according to range.
10	Readout Tubes	Neon indicator tubes display the instrument readout from left to right, with the most significant digit displayed by the left-most tube. Each tube also displays a decimal point which, is operated by the RANGE switches.
11	115/230 Volt Switch	Slide switch selects the ac operating voltage for the instrument. Switch is not accessible until bottom dust cover is removed. NOTE: Refer to paragraph 2-7 for conversion instructions.
12	AC Line Connector	Mates with three-wire line cord for connection to 115/230 volt, 50 Hz to 500 Hz ac line.

Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (Sheet 2 of 2)

2-12. OPERATIONAL CHECK

2-13. This test verifies satisfactory operation of the instrument, using only front panel controls. It is intended as a quick functional check only. In consideration of possible wide variation in ambient temperature, the tolerances on readouts have been extended accordingly.

a. Connect the Model 8100A to a source of 50 Hz to 500 Hz ac power or use the optional battery pack, as described in paragraph 2-7.

b. Jumper the LO terminal to the GUARD terminal with the shorting link provided and set the Model 8100A controls as follows:

POWER	ON
Function	VDC
RANGE	1000
FILTER	ON

c. The instrument readout should be 000.0 ±3 digits. The polarity indicator should register either "+" or "–".

d. Connect a shorting link between HI and LO INPUT terminals. Press, in turn, the 100 volt, 10 volt, and 1 volt RANGE switches. The instrument readout should be 00.00 ±3 digits, 0.000 ±3 digits, and .0000 ±1 digit, respectively.

e. Press the VAC function switch and the 1000 volt RANGE switch. The instrument readout should be between 000.0 and 001.5, with shorted INPUT terminals. The polarity indicator should not illuminate.

f. Remove the INPUT shorting link and press the KΩ function switch and 1 volt RANGE switch. Instrument readout should be full scale at 1.1999 (instrument attempts to measure infinite resistance between input terminals).

g. Short circuit the INPUT terminals. Instrument readout should be .0004 or less. Remove the short at the input.

NOTE!

Resistance of connections and shorting link must be less than 100 milliohms to obtain the indicated reading.

h. Press the 10 MΩ function switch. Instrument readout should be 11.999.

i. Short circuit the INPUT terminals. Instrument readout should be 0.004 or less.

2-14. A detailed performance test is given in paragraph 4-19 of the Maintenance section of the manual. It verifies performance of the instrument within the basic accuracy specifications using standard input signals and front panel controls only. It is suggested for use as a receiving inspection test for the instrument and to determine if the instrument is in calibration.

2-15. DC VOLTMETER OPERATION

2-16. The Model 8100A measures dc voltages in both polarities from 0 to 1000 volts, with 20% overrange capability in each of the four ranges. An active 2-pole filter is included and provides two modes of filtering. It may be switched in, if desired, to reduce the instrument response to noise. To operate the instrument as a dc voltmeter, proceed as follows:

a. Press the VDC function switch to place the instrument in dc voltage mode.

b. Select the desired full-scale voltage range by pressing the corresponding RANGE switch.

c. Select increased noise rejection by operating the FILTER switch (see filter specifications in the Section I). Note that response time to rated accuracy is increased from 0.5 seconds to 1.5 seconds with filter IN.

d. Connect the voltage to be measured to the INPUT terminals. The automatic polarity circuitry of the Model 8100A will activate appropriate circuitry in the instrument and the front panel polarity indicator will register a "+" if the HI input terminal is positive with respect to the LO terminal and "–" if the HI input terminal is negative with respect to the LO terminal.

2-17. AC VOLTMETER OPERATION

2-18. The Model 8100A measures ac voltage from 0 to 1000 volts at frequencies of 30 Hz to 20 kHz, with 20% overrange capability in each of four ranges. To operate the instrument as an ac voltmeter, proceed as follows:

a. Press the VAC function switch to place the instrument in ac voltage mode.

b. Select the desired full-scale voltage range by pressing the corresponding RANGE switch.

c. Connect the voltage to be measured to the INPUT terminals.

2-19. OHMMETER OPERATION

2-20. The Model 8100A measures resistance in five full-scale ranges of 1k, 10k, 100k, 1000k, and 10 megohms, with 20% overrange capability in each range. To operate the instrument as an ohmmeter, proceed as follows:

a. Select the KΩ function switch for measurement of resistances between 0 and 1000k and select the 10 MΩ switch for measurement of resistances between 1 and 10 megohms.

b. Select the desired full-scale resistance range in kilohm mode by pressing the corresponding RANGE switch. In 10 megohm mode, the range is fixed independent of the four range switches.

c. Connect the resistance to be measured to the INPUT terminals.

NOTE!

In both KΩ and 10 MΩ modes, the internal voltage arrangement is such that the HI input terminal is positive with respect to the LO input terminal.

2-21. OPERATING NOTES

2-22. Overload Protection

2-23. The Model 8100A is fully protected against overload in each function and on all ranges. In ac and dc voltage modes, ±1200 volts dc or 1700 volts peak ac from 30 Hz to 20 kHz can be applied indefinitely on any range without damage. In ohms mode, 130 volts rms may be applied indefinitely on the 1 kilohm range without damage, and 230 volts rms may be applied indefinitely on the remaining ohms ranges without damage.

2-24. Use of Guard Terminal

2-25. The instrument contains an isolated inner chassis, which is connected to the GUARD terminal on the front panel. When properly connected, the guard chassis reduces measurement errors due to common-mode currents. Ordinarily, the GUARD terminal is strapped to the LO terminal; however, it may also be driven by a separate guard voltage, with connections at a remote point. It should be noted that the guard voltage must be within 100 volt dc or peak ac of the LO input terminal.

2-26. APPLICATIONS

2-27. Transistor Testing

2-28. In KΩ and 10 MΩ modes, the Model 8100A produces a maximum of 9 volts, with 10 kilohms to 10 megohms in series, depending on range. The maximum current flowing in the unknown resistance is 0.7 milliamp. The maximum power dissipated in the unknown resistance is 2.0 milliwatts on the 1 kilohm range, decreasing by an order of magnitude per range to 200 nanowatts maximum at 10 megohms. Consequently, the instrument may be used to safely test most transistors. In both KΩ and 10 MΩ modes, the internal voltage arrangement is such that the HI input terminal is positive with respect to the LO terminal.

2-29. DBM Measurement

2-30. To use the Model 8100A as an ac output meter, terminate the circuit to be measured in its characteristic impedance and connect the Model 8100A directly across the load. For example, to measure output levels of a circuit having a characteristic impedance of 600 ohms, connect a 600-ohm load to the Model 8100A INPUT terminals. The resulting readout may be converted to dbm using the information provided in Figure 2-2.

MODEL 8100A READOUT	DBM LEVEL FOR 1 VOLT RANGE (1 mw in 600 Ω)
.0138	−35
.1092	−17
.2182	−11
.3083	− 8
.4352	− 5
.5490	− 3
.6150	− 2
.6897	− 1
.7746	− 0
.8700	+ 1
.9760	+ 2
Add 20 db for each range above one volt.	

Figure 2-2. AC VOLTAGE TO DBM CONVERSION TABLE FOR 600- OHM CIRCUITS

2-31. Measurement of High Resistances

2-32. In this application, the Model 8100A together with a stable external dc voltage is used to measure resistances in excess of 10 megohms.

a. Measure and record the external voltage, E_{bb}; then connect the equipment as shown in Figure 2-3.

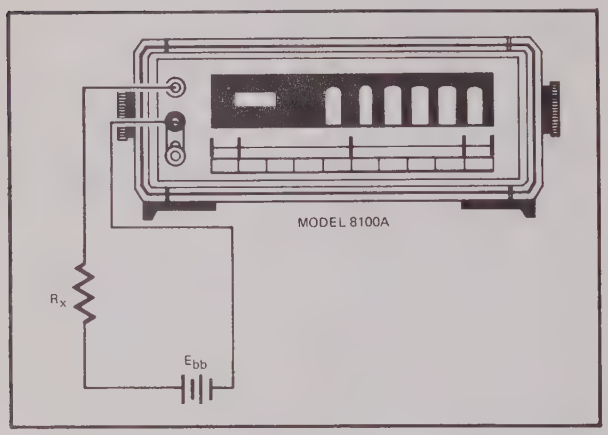


Figure 2-3. CIRCUIT CONNECTIONS FOR MEASUREMENT OF HIGH RESISTANCES

b. Record the Model 8100A readout.

c. Using the following calculations, determine the value of the unknown resistance, R_x.

$$R_x = \left(\frac{E_{bb}}{E_m} - 1 \right) R_m$$

Where E_{bb} = External DC Voltage (volts dc)
E_m = Model 8100A readout in step b. (volts dc)
R_m = 10 Megohm (10^7) $\pm$0.03%

2-33. Use As A Null Detector

2-34. The Model 8100A, with battery option, is ideally suited to many applications requiring a null detector. The high dc input resistance (10 megohms) and the autopolarity feature of the instrument make it ideal for monitoring small voltage differences in bridge circuits, potentiometers, and other measuring devices. Where circuit adjustment is required, the circuit is simply adjusted for a readout of all zeros on the Model 8100A, which provides 100 microvolt resolution on the 1 volt range.

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. This section contains the theory of operation of the Model 8100A Digital Multimeter. In the general discussion, the instrument function is examined at the block diagram level. The detailed circuit description is keyed to the schematics at the back of the manual.

3-3. GENERAL THEORY

3-4. System Description

3-5. The Model 8100A consists of three main sections: the buffer, the analog-to-digital (A-to-D) converter, and the display. A simplified block diagram of the instrument is shown in Figure 3-1. The buffer accepts the input signal and converts it into a voltage suitable to drive the A-to-D converter. It scales and conditions all inputs and it performs ac to dc conversion. The A-to-D converter accepts the buffer output, determines the polarity of the voltage, and converts the voltage into a binary coded decimal (BCD) output. The analog storage circuit is used to retain digit information between measurement cycles so that a continuous display is provided. The display circuit accepts the BCD output from the A-to-D converter and converts it into a 10-line decimal output, which operates the readout tubes. The power supplies provide operating voltages for each of the sections, a stable master reference voltage, and clock signals, which are the time base for the entire instrument.

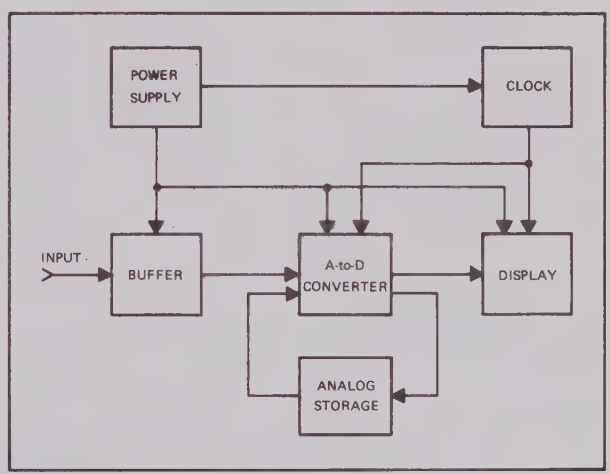


Figure 3-1. MODEL 8100A SIMPLIFIED BLOCK DIAGRAM

3-6. Buffer

3-7. The principal parts of the buffer are a resistive input divider, which scales the dc input voltages to 1 volt full scale; an active, switchable, two-pole input filter, providing an instrument response of either 0.5 or 1.5 seconds, which removes unwanted ac signals from the dc input; and a low-drift, high-gain amplifier having a high input impedance. Depending on the function selected at the front panel, the buffer is connected in one of four modes of operation: dc voltage (VDC), kilohms (KΩ), 10 megohm (10 MΩ), or ac voltage (VAC).

3-8. When the instrument is in dc voltage mode, the buffer is connected as shown in Figure 3-2. The dc input voltage (E_{in}) is applied to a voltage divider. The divider

output is applied through the input filter to the buffer amplifier. The amplifier is connected as an inverting voltage follower and provides an output to the A-to-D converter which is the negative of the scaled-down input. The two diodes inside the feedback loop provide a threshold step, which supplies polarity information to the A-to-D converter. Resistor R_L is the output load resistance.

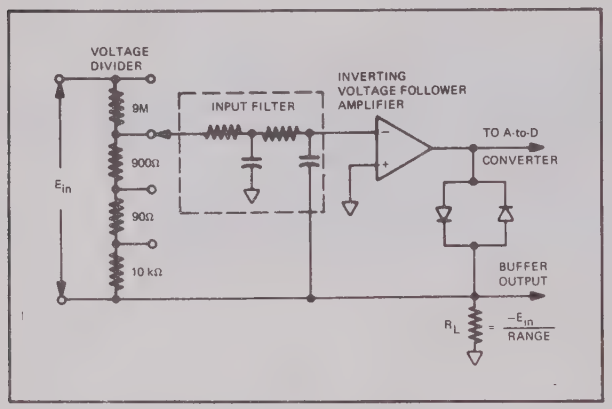


Figure 3-2. DC VOLTAGE MODE SIMPLIFIED DIAGRAM

3-9. In kilohm mode, the buffer is connected as shown in Figure 3-3. The same input divider, filter, and amplifier

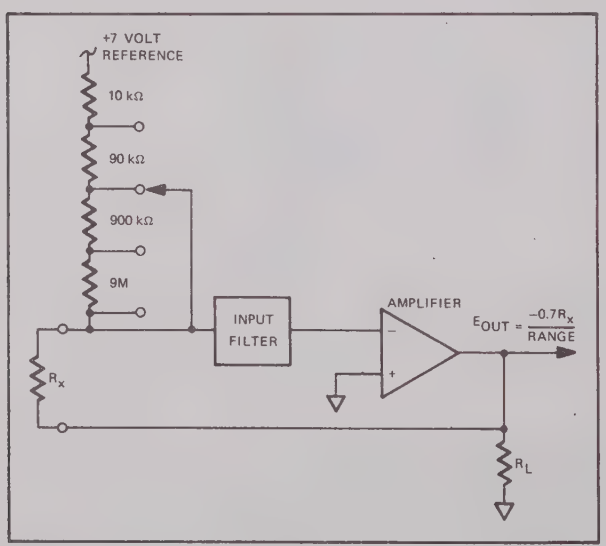


Figure 3-3. KILOHM MODE SIMPLIFIED DIAGRAM

are used, except the input divider is connected to the +7 volts reference. In this circuit arrangement, the input divider is the input resistor of an operational amplifier in which the +7 volt reference forms the input voltage and the unknown resistor (R_x) forms the feedback resistance. A voltage proportional to R_x is applied to the A-to-D converter and is equivalent to −0.7 volts full scale when the proper input divider tap is selected.

3-10. In 10 megohm mode, the buffer is connected as shown in Figure 3-4. The +7 volt reference voltage is

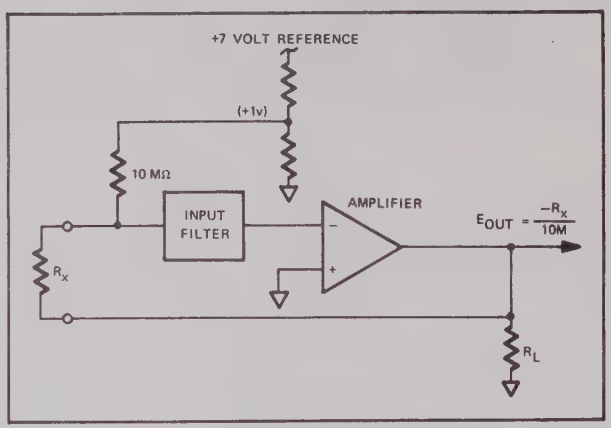


Figure 3-4. 10 MEGOHM MODE SIMPLIFIED DIAGRAM

divided down to 1 volt to limit the full-scale output of the buffer to 1 volt. In all other respects, the operation in 10 megohm mode is analagous to kilohm mode operation.

3-11. In ac voltage mode, the buffer is connected as shown in Figure 3-5. In this arrangement, the amplifier is

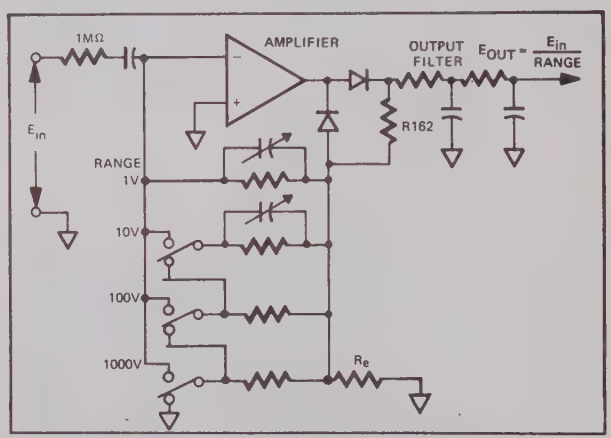


Figure 3-5. AC VOLTAGE MODE SIMPLIFIED DIAGRAM

used as an operational rectifier. A pair of rectifier diodes is placed inside a strong negative feedback loop, and a negative ac feedback signal proportional to the input voltage is developed across resistor R_e. A half wave rectified dc signal proportional to the input is developed across R162. The proper scale factor is determined by the feedback resistors, which are controlled by the front panel range switches. The positive half-cycles across R162 are filtered by a two-stage RC filter to provide a positive one volt output to the A-to-D converter that is scaled in terms of the rms value of a sine wave. Table 3-1 gives the full-scale buffer outputs for each of the instrument functions.

Table 3-1. BUFFER OUTPUTS

FUNCTION	FULL-SCALE BUFFER OUTPUT (VOLTS DC)
+VDC	−1
−VDC	+1
KΩ	−0.7
10 MΩ	−1
VAC	+1

3-12. A-to-D Converter

3-13. The A-to-D converter employs the unique recirculating-remainder (R^2) A-to-D conversion technique developed by FLUKE. A simplified diagram of the A-to-D converter and associated circuitry is shown in Figure 3-6. Accompanying the diagram is a chart showing the sequence of operation for an input of 0.6352 volts.

3-14. The A-to-D converter digitizes the input serially in four 4-millisecond time periods, with each period divided equally into digitizing and display periods, A and B. At the start of the measurement sequence, period 1A, the A-to-D converter samples the 0.6352 volt input. Then the analog output voltage from the X10 amplifier causes the comparator to output to the voltage controlled oscillator (VCO), and the VCO produces pulses which are entered into the counter. When the total pulse count equals the most significant digit of the input or 6, the counter stops. The ladder produces a series of six 0.1 volt steps which correspond to the counter output. The remainder of 0.0352 volt is amplified by the X10 amplifier and held in sample and hold capacitor C1. See C1 in Figure 3-6. The display circuitry decodes the counter output and displays the 6 in period 1B. At the beginning of period 2, the 0.6352 volt input is disconnected from the input of the A-to-D converter and the 0.352 volt output of the sample and hold circuit is digitized and displayed as the new input. Successively, the remainders of 0.52 and 0.2 volts are digitized and displayed in the same manner. Although the four digits are digitized and displayed one at a time, the process proceeds at a sufficiently high rate of speed so that the display appears continuous to the eye.

3-15. The input voltage is sampled every 300 milliseconds. Since it only requires 20 milliseconds to digitize the input, a storage circuit is provided which stores a voltage representing each of the four digits on each of four capacitors. This stored information supplies the input during the remaining fourteen 20-millisecond periods, until the voltmeter is ready to sample the input voltage again.

3-16. Refer to the simplified A-to-D converter diagram in Figure 3-7 and assume that a +0.6352 volt signal is applied to FET switch Q16. The polarity sensing circuit turns on Q16 and turns off Q12 and Q17 in response to the positive input signal and the stage −1 signal from the ring counter. (Note: The positive input refers to the signal at the input of the A-to-D converter. The actual instrument input signal is negative, but is inverted by the buffer.) The input signal is thus applied to the positive input of amplifier A2. The feedback loop for A2 is closed through resistor R98, which is chosen to give an amplifier gain of 70. Thus, when the output of A2 is 7 volts, the voltage at e_s will be 0.1 volts. With 0.6352 volts at the positive input, amplifier A2 will attempt to place the same voltage at the negative input of A2; however, as the output of A2 swings past 7 volts, the comparator produces an output that turns on the VDC. The VCO produces a series of pulses, which are entered into the counter. The counter output causes the ladder to place a corresponding series of 0.1 volt steps into point e_s. When six pulses have entered the counter, the ladder output will be 0.6 volts and the output of A2 will drop below 7 volts. At this point, the VCO stops generating pulses and the voltage at e_s remains at 0.6 volts plus a remainder of 0.0352 volts which is applied to e_s through R98. The resulting voltage at e_R will then be exactly 0.352 volts or, in other words, ten times the remainder. The amplified remainder is applied through switch Q35 to the first sample and hold capacitor, C34.

3-17. Digitizing the 6 requires approximately 2 milliseconds or half of the first digitizing period, as shown in Figure 3-6. The 6, which is stored in the counter during the digitizing process, is then displayed by the display circuit. After approximately 2 milliseconds of display time, the display is turned off and the counter is reset to zero. Switch Q35 is then turned off, leaving capacitor C34 charged to 0.352 volts. At the same time, Q16 is switched off, removing the input from the A-to-D converter for the duration of the digitizing cycle, and the ring counter switches to stage 2, turning on switches Q36 and Q39. The 0.352 volts is then applied through Q36 to the input of A2 and is digitized as the new input signal. The resulting amplified remainder of 0.52 volts is stored in the second sample and hold capacitor, C35, while the 3 is digitized and displayed in the second readout tube. The process is repeated twice more, digitizing both the 5 and the 2, with the amplified remainder alternately supplied by the two sample and hold capacitors.

3-18. If the A-to-D converter input voltage had been negative, the polarity sensing circuit would have turned on

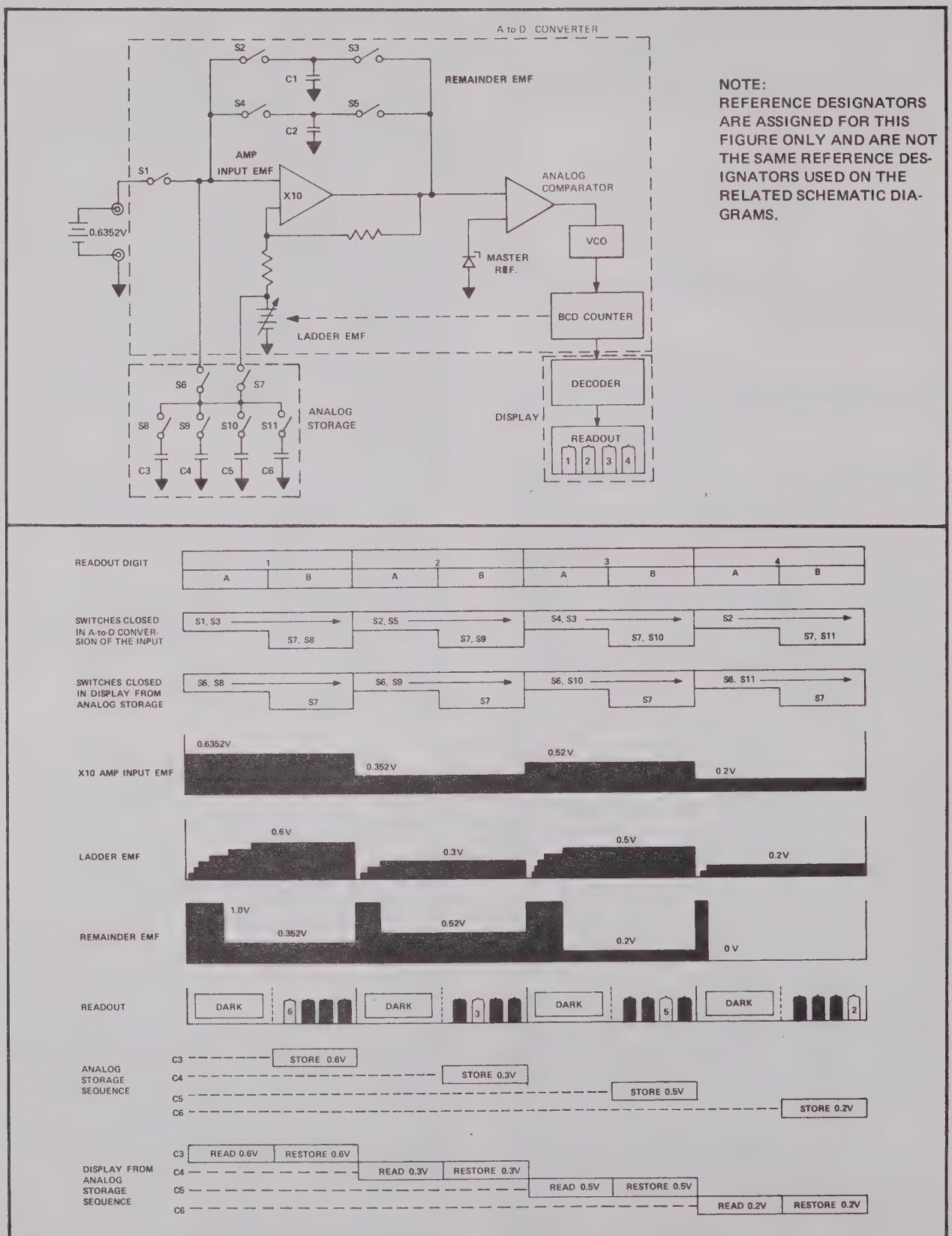


Figure 3-6. RECIRCULATING-REMAINDER A-to-D CONVERSION

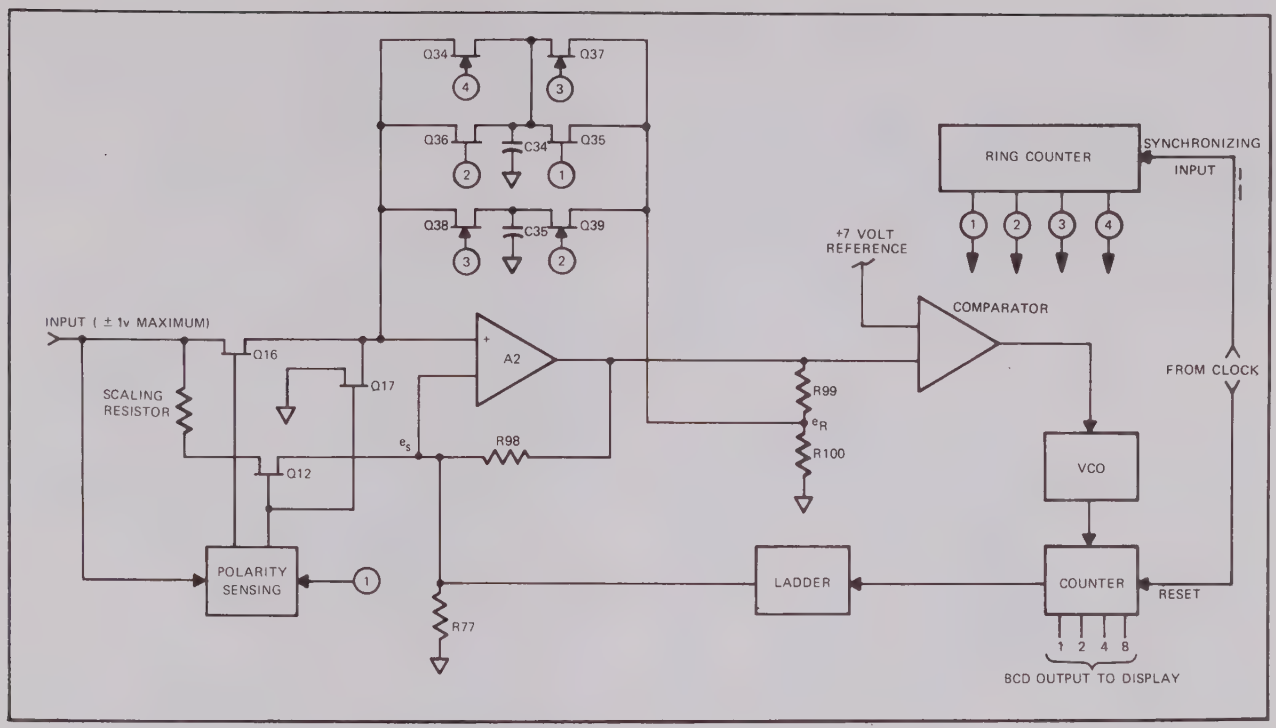


Figure 3-7. A-to-D CONVERTER SIMPLIFIED DIAGRAM

switch Q12 and Q17 instead of Q16 during the first period, and the voltage would have been applied to the negative input of A2, with Q17 holding the positive input of A2 at ground. With a negative input, both the ladder and resistor R98 are used as current summing resistors, since the negative input of amplifier A2 will be at virtual ground. The scaling resistor is the operational input resistance and is adjusted to set the amplifier gain to proper value. After the first digit is digitized, Q12 and Q17 are switched off and the remainder terms are digitized in the same manner as previously explained.

3-19. Analog Storage

3-20. A simplified diagram of the analog storage circuit is shown in Figure 3-8. This circuit accepts the 4-bit BCD output of the counter and converts it into an analog voltage which corresponds to the displayed digit. The analog voltage is applied to the storage capacitors through FET input switch Q28 during the display half of each clock cycle. Each of the four analog voltages is stored in a separate capacitor which is switched into the circuit by the ring counter at the same time that the corresponding digit is being displayed. When the measure/store multivibrator switches to the storage mode, FET output switch Q29 is turned on and the input voltage is disconnected from the input of the A-to-D converter. The analog voltages in the

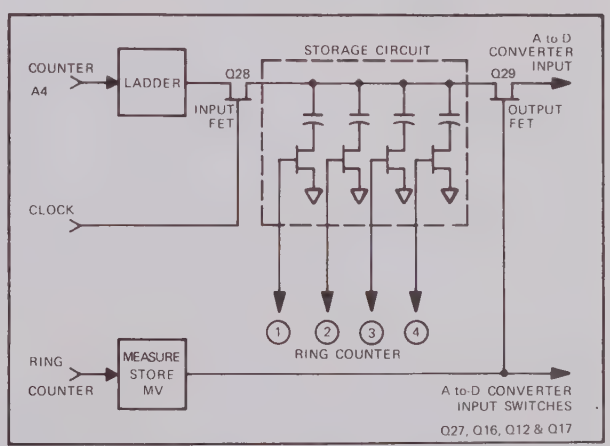


Figure 3-8. ANALOG STORAGE SIMPLIFIED DIAGRAM

storage circuit are then applied, digit by digit, to the A-to-D converter input. The voltages are digitized, displayed, and then re-stored in the analog storage circuit. The storage readout cycle lasts for approximately 300 milliseconds, after which time the measure/store multivibrator switches to measure mode and the A-to-D converter input is reconnected to the input signal. There are approximately 14 cycles of storage for every measurement cycle, which provides a continuous display that changes (input is sampled) three times per second.

3-21. Display

3-22. The 4-line BCD output from the A-to-D converter, containing the digit information, is applied to the decoder/driver. The decoder/driver provides a 10-line output, which is connected to the readout tube cathodes as shown in Figure 3-9. All readout tube cathodes are connected in

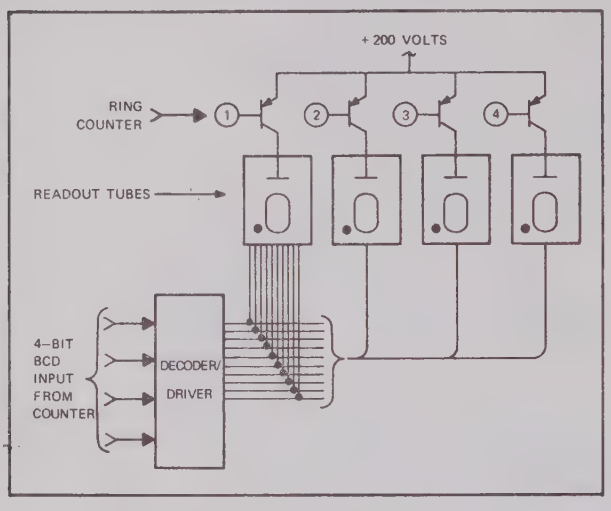


Figure 3-9. DISPLAY SECTION SIMPLIFIED DIAGRAM

parallel so that the same digit is turned on in each tube. However, only the readout tube corresponding to the proper digit will be turned on by the ring counter. Therefore, all four digits are displayed on a time-share basis using one counter and one decoder/driver. The display cycle occurs during the second half of each digitizing period, as shown in Figure 3-6, whereas digitizing in the A-to-D converter occurs during the first half of the period.

3-23. Power Supply and Clock

3-24. All operating voltages for the Model 8100A are produced by a series of regulated power supplies that derive their voltages from a −18 volt regulator (see Figure 3-10). In line operated instruments, the −18 volt regulator is supplied raw voltage by a transformer/rectifier; and in battery operated instruments, voltage is supplied by rechargeable batteries. The −18 volt regulator output is used throughout the instrument as an operating voltage and is also applied to the inverter input. The inverter provides +17 volts dc to the +15 volt regulator which, in addition to supplying instrument operating voltages, serves as source for the +7 volts reference. The inverter also provides 200 volts, which drives the readout tubes, and +5 volts to operate the integrated logic circuitry. Finally, the inverter supplies the 250 Hz clock signal.

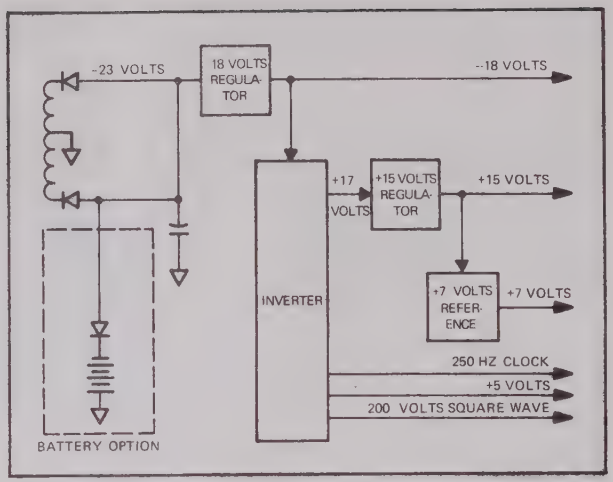


Figure 3-10. POWER SUPPLY AND CLOCK SIMPLIFIED DIAGRAM

3-25. CIRCUIT DESCRIPTION

3-26. Buffer

3-27. INPUT RANGE DIVIDER. In dc voltage mode, the input binding posts are connected across a four-position range divider consisting of three closely matched wirewound resistors, R158, R159, and R160 and a precision metal film resistor, R156. Resistor R157 is adjusted to provide an exact ratio between R156 and the other divider resistors. Depending on the range selected, the divider scales the input voltage down by a ratio of 1, 10, 100, or 1000 so that the output voltage of the divider will always be 1 volt full scale. In kilohm mode, the bottom of the input divider (R160) is disconnected from the LO binding post and connected to the +7 volt reference. When so connected, the divider acts as the current determining network for ohms measurement. Selection of the proper range places the required portion of the divider in series with the +7 volt reference. In all kilohm ranges, the voltage developed across the unknown resistor is 0.7 volts at full scale. In 10 megohm mode, the bottom end of the divider is connected to divider R152, R154, which is adjusted by R153 to provide an output of 1 volt. This 1 volt output sets the current through the entire range divider to provide the proper scale factor; full scale output in 10 megohm mode is 1 volt.

3-28. INPUT FILTER The output of the range divider is applied to an active, two-pole filter consisting of resistors R27 and R28 and capacitors C10 through C13. When the FILTER switch is ON, the filter consists of R27 and C10 in the first section and R28 and C12 in the second section and provides a settling time of 1.2 seconds and noise rejection of 60 db at 60 Hz. When the FILTER switch is OFF, C11 is placed in series with C10 and C13 is placed in series with C12, thereby reducing the settling time to 0.25 second and

the noise rejection to 20 db at 60 Hz. Diodes CR11 and CR12, in conjunction with R27, protect both the filter and the buffer amplifier from excessive input voltages. In the 10 volt dc range, R27 is shorted out, since the output impedance of the range divider is 1 megohm and R27 is not needed.

3-29. BUFFER AMPLIFIER The buffer amplifier consists of transistors Q77, Q79, and Q80 and amplifier A1. The first stage amplifier is Q77, a low-noise, low-drift JFET pair operating in common-source configuration. Potentiometer R175 is the zero adjustment control, which in conjunction with R176, R177, and R193 is used to reduce the initial offset of Q77 to zero. The output of Q77 drives A1, a monolithic operational amplifier that provides most of the voltage gain. Capacitor C51 is placed around A1 to provide a smooth roll-off through unity gain. Transistor Q79 is a common base output stage which raises the output impedance of the amplifier as high as possible. To avoid degrading the high output impedance, Q79 operates into a constant current load, Q80.

3-30. In dc voltage, kilohm, and 10 megohm modes, the feedback loop for the unity gain buffer amplifier is completed through diodes CR14 and CR15 which provide a voltage step around zero to drive the polarity sensing circuit. Resistor R174 is the load resistor for the amplifier. In ac voltage mode, the buffer amplifier is connected as an operational amplifier, with R24 functioning as the input resistor. The input signal is coupled through capacitor C9 to the gate of Q77 and the negative feedback loop is completed through the range resistors, R29, R30, R31, and R32. Diodes CR14 and CR15 act as an operational rectifier in ac voltage mode. A positive, half-wave rectified dc voltage, proportional to the average value of the ac input, is developed across R162 and R174. This voltage is smoothed by a two-stage filter composed of resistors R35 and R36 and capacitors C19 and C20. Potentiometer R34 R34 (ACV CAL) is adjusted to provide a filter output of 1 volt for a full scale input on any instrument range. Because the input capacity of Q77, together with additional stray capacities, causes an additional pole in the loop response of the ac converter, trimmer capacitors C14 and C15 are provided on the two lowest ranges to adjust the frequency response through 20 kHz. Frequency adjustment is not necessary on the upper two ranges because of the low resistance of R31 and R32.

3-31. A-to-D Converter

3-32. CLOCK The clock signal, which is the master timing signal for the A-to-D converter, is taken from several windings on the inverter transformer, T102. T102-2 supplies a gate control signal for the analog storage circuit. The signal at T102-10 is used to strobe the readout tubes and synchronize the ring counter. Both T102-10 and T102-8 signals are applied to NAND gate A3A to provide a delayed reset pulse for counter A4. The timing diagram for the A-to-D converter is shown in Figure 3-11. Note that the measurement cycle is actually one period longer than was shown in the simplified diagram of Figure 3-6. The added period is set aside at the beginning of each measurement cycle for removal of the zero offset of the A-to-D converter amplifier.

3-33. RING COUNTER. The five-stage ring counter consists of transistors Q19 through Q24 and associated components. The ring counter will free run at a frequency slightly less than the clock frequency. However, the clock signal forces the counter to speed up, thereby synchronizing the five counter periods with the clock. The purpose of Q24 is to prevent two pulses from entering the ring at one time. At the end of the fifth period in the measurement cycle, the ring counter supplies a synchronizing signal to the measure/store multivibrator.

3-34. POLARITY SENSING CIRCUIT . The polarity sensing circuit consists of transistors Q13, Q14, Q15, and associated components. At the beginning of the second period in every measurement cycle, Q13 is turned on by the second stage signal from the ring counter. As soon as Q13 turns on, the polarity sensing circuit responds to the voltage which appears at R40. If the instrument input voltage is negative, the voltage at R40 will be positive, transistor Q15 will conduct, and the signal at the collector of Q15 in conjunction with the signal from the measure/store multivibrator (Q25) will turn on FET switch Q16. Switch Q16 then connects the positive buffer output voltage at test point 9 (TP9) to the positive input of the A-to-D converter amplifier. If the instrument input is positive, Q14 will conduct and the signal at the collector of Q14 in conjunction with the signal from Q25 will turn on FET switches Q12 and Q17. The negative buffer output will then be applied through scaling resistors R50 and R51 and switch Q12 to the negative input of the A-to-D converter amplifier. At the same time, the positive input of the amplifier will be connected to ground through switch Q17. Resistors R186 and R187 provide a small offset correction voltage to the positive input. The polarity indicator remains on during storage cycles, since the polarity sensing circuit monitors the input signal. During storage cycles, Q12, Q16 and Q17 are held off by a signal from the measure/store multivibrator.

3-35. Two different circuit configurations of the A-to-D Converter Amplifier are used on the Model 8100A. Con-

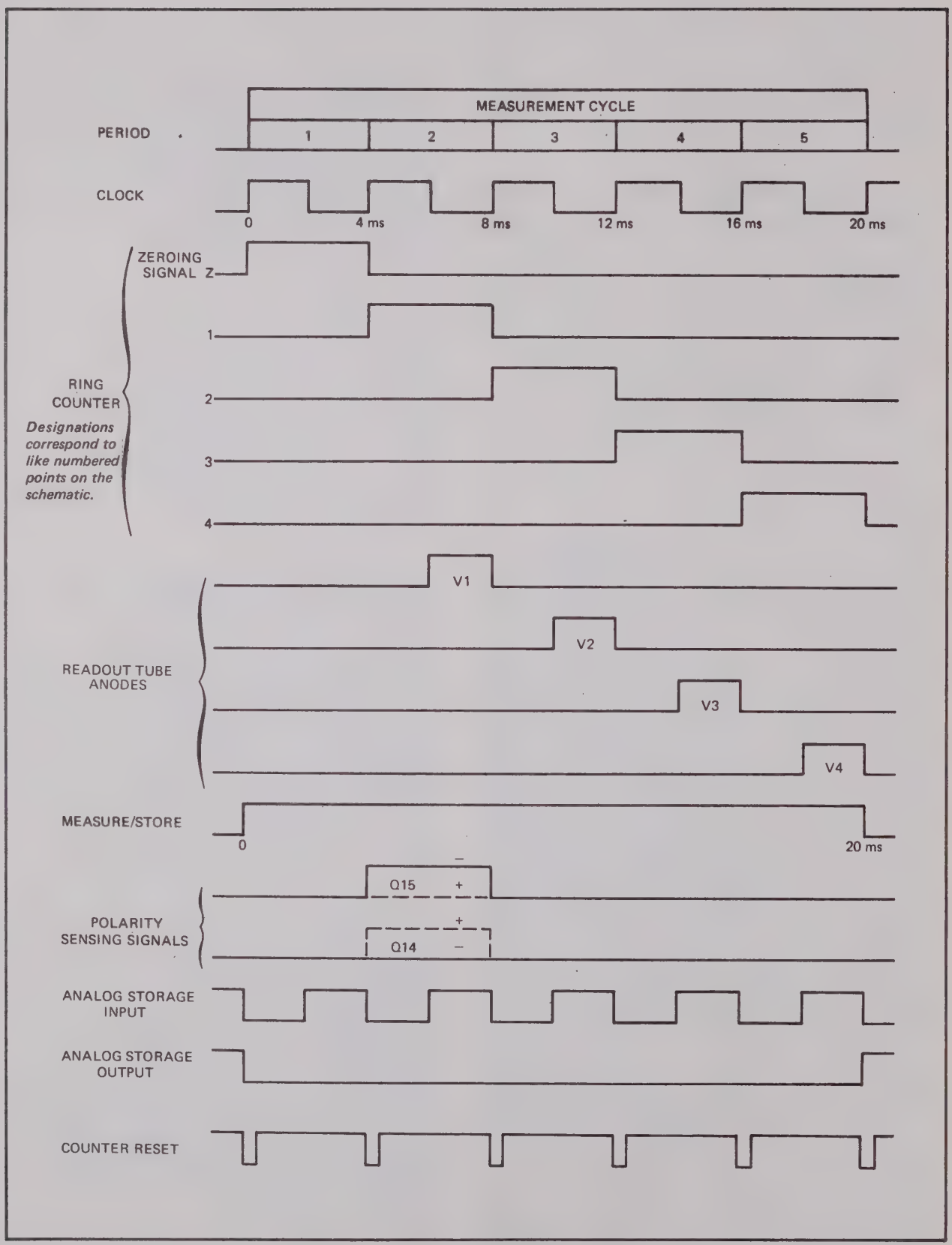


Figure 3-11. TIMING DIAGRAM

sequently, two different schematics for the following circuits are provided at the rear of this manual. Refer to the serial numbers listed in the schematic block diagram title block to determine which diagram is applicable to your instrument. At the beginning of each paragraph of circuit descriptions, serial number effectivity is also listed.

3-36. A-to-D CONVERTER AMPLIFIER. This paragraph applies to instruments bearing serial numbers 123 thru 3409 and 3420 thru 4097. The amplifier consists of dual FET Q53, operational amplifier A2, and associated circuitry. Transistors Q76 and resistor R110 comprise a clamp, which prevents amplifier A2 from saturating while the output is above 7 volts. Transistor Q83 and resistor R184 clamp the output of amplifier A2 on strong negative signals, such as FET switching transients. The remainder feedback loop is completed through the comparator, which consists of transistor Q54 and diodes CR29 and CR30, and through the remainder resistor R98 to the input of A2. During the first period, or zeroing period, of each measurement cycle, transistors Q58 and Q18 are switched on by the ring counter. Transistor Q58 connects the output of the amplifier to the zero-holding capacitor C37, while Q18 connects the positive input of the amplifier to ground. This operation places the offset of Q53 across C37 and effectively removes it for the balance of the measurement cycle. The amplifier is able to satisfy itself through these feedback loops as long as the input does not exceed 0.1 volts. When the input exceeds 0.1 volt, the output of A2 attempts to rise above 7 volts, which causes the comparator to output to the VCO through current source Q61.

3-37. A-to-D CONVERTER AMPLIFIER. This paragraph applies to instruments bearing serial numbers 3410 thru 3419 and 4098 and on. The amplifier consists of dual FET Q53, operational amplifier A2, and associated circuitry. Transistors Q76 and resistor R110 comprise a clamp which prevents amplifier A2 from saturating while the output is above 7 volts. Diode CR47 clamps the output of amplifier A2 on strong negative signals, such as FET switching transients. The remainder feedback loop is completed through the comparator, which consists of transistors Q86 through Q89, and through the remainder resistor R98 to the input of A2. The amplifier is able to satisfy itself through these feedback loops as long as the input does not exceed 0.1 volt. When the input exceeds 0.1 volt, the output of A2 attempts to rise above 7 volts, which causes the comparator to output to the VCO through current source Q89. During the first period or zeroing perio of each measurement cycle, transistors Q58, Q85 and Q18 are switched on by the ring counter. Transistor Q58 connects the output of the amplifier to the zero holding capacitor C37, while Q18 connects the positive input of the amplifier to ground. This operation places the offset of Q53 across C37 and effectively removes it for the balance of the measurement cycle.

3-38. VOLTAGE CONTROLLED OSCILLATOR. This paragraph applies to instruments bearing serial numbers 123 thru 3409 and 3420 thru 4097. The VCO consists of multivibrator Q59, Q60. The VCO has no output until it is supplied current by current source Q61. When the output of A2 exceeds 7 volts, the difference is passed on to Q61 by the comparator and Q61 begins to conduct. The pulse repetition rate of the VCO is proportional to the magnitude of the driving current. The greater the current flowing into the base of Q59, the greater the number of pulses per unit time. The output of the VCO is applied to the input, pin 1, of counter A4.

3-39. VOLTAGE CONTROLLED OSCILLATOR. This paragraph applies to instruments bearing serial numbers 3410 thru 3419 and 4098 and on. The VCO consists of multivibrator Q59, Q60. The VCO has no output until it is supplied current by current source Q89. When the output of A2 exceeds 7 volts, the difference is passed on to Q89 by the comparator and Q89 begins to conduct. The pulse repetition rate of the VCO is proportional to the magnitude of the driving current. The greater the current flowing into the base of Q59, the greater the number of pulses per unit time. The output of the VCO is applied to the input, pin 1, of counter A4.

3-40. COUNTER The counter is a monolithic ripple counter, having an output which corresponds to a standard 8-4-2-1 binary code. The VCO output is applied to the clock input of the counter and the reset pulse from A3A is applied to the clear input. The output of counter A4 is applied to the decoder/driver, A5, and the ladder.

3-41. LADDER The output of counter A4 is applied to the ladder switches and their drivers, transistors Q40 through Q51. The ladder switches drive two ladders. The primary ladder consists of precision resistors R79, R84, R89, R94, and R77 and produces an output that corresponds to the actual value of the digital input. The secondary ladder, which drives only the analog storage circuit, consists of resistors R75, R78, R83, R88, and R93 and produces an output that is slightly in excess of the actual value of the digital input. Each ladder comprises a 4-bit, weighted-resistor digital-to-analog converter. The analog output of the ladders is weighted in terms of seventieths of the reference voltage (+7 volts) so that they can be programmed for a 0.1 volt output for each digital bit at the input.

3-42. SAMPLE AND HOLD. The sample and hold circuit consists of FET switches Q34 through Q39 and capacitors C34 and C35. During the second period of the measurement cycle, the amplified remainder is applied to C35; however, Q35 is inhibited from conducting during the first half of the period by the clock signal which is coupled through diode CR36 to its gate. During the second half of the second period, Q35 is switched on and the amplified remainder is applied to capacitor C34. During the third period, Q35 is switched off, Q36 is switched on, and the remainder is applied through FET switches Q34 and Q27 to the input of amplifier A2. At the same time, Q39 is switched on and the next remainder is applied to capacitor C35. During the fourth period, Q39 is switched off and Q37 and Q38 are switched on. The input is then supplied by the remainder voltage held on C35, while the next amplified remainder is stored on C34. In the final period of the measurement cycle, only Q34 is switched on to supply the final remainder voltage to the input of A2. Upon completion of the fifth period, the A-to-D converter input is connected to the instrument input voltage (if in measure mode) or the analog storage output voltage (if in storage mode) and the circulation of the new remainder proceeds in the same manner as before.

3-43. Analog Storage

3-44. The analog storage circuit consists of the secondary ladder (discussed in paragraph 3-41), the measure/store multivibrator, and the storage circuit.

3-45. MEASURE/STORE MULTIVIBRATOR. The measure/store multivibrator, consisting of transistors Q25 and Q26, is basically a one-shot multivibrator with dual synchronizing inputs. The measurement cycle, which is approximately 20 milliseconds in duration, is coincident with conduction of Q25; and the storage cycle, which is approximately 330 milliseconds in duration, is coincident with conduction of Q26. The multivibrator is triggered at the end of each measurement cycle by the trailing (negative) edge of the signal at the collector of Q24. During the measure cycle, a signal is coupled to the polarity sensing circuit from the collector of Q25. This signal enables switch Q16 for positive signal measurement or switches Q12 and Q17 for negative signal measurement. In storage mode, this signal is not present and, consequently, the input voltage will not be connected to the A-to-D converter.

3-46. STORAGE CIRCUIT. The storage circuit consists of FET switches Q28 through Q33 and capacitors C30 through C33. The output of the secondary ladder is supplied to the appropriate storage capacitor through Q28, which is switched on during display time. The first digit is stored in C30, the second in C31, the third in C32, and the fourth in C33. When the measure/store multivibrator switches to storage mode, Q29 is switched on and the analog voltages stored in the capacitors are applied, serially, to the input of A2.

3-47. Display

3-48. The decoder/divider is a monolithic BCD-to-decimal decoder, which accepts the 4-bit BCD output of counter A4, decodes each digital word, and selects one of ten decimal output drivers. The ten driver outputs are applied to the readout tube cathodes.

3-49. The readout tubes are operated by the 200 volt square wave, which originates in the power supply and corresponds in frequency to the clock. During the second half of each clock period (display time), the inverter supplies the full 200 volts to the anode drive line. The anodes are turned on by switches Q67 through Q70 and current sources Q71 through Q74. The switches, which are operated by the ring counter, turn on only one readout tube during each period of the measurement cycle. At the same time, the output of the decoder/driver is applied to the appropriate cathode of each of the four readout tubes and the digit is then visually presented in proper decimal position.

3-50. The overrange digit lamp, DS2, is operated by transistor Q66, which is connected in an AND configuration with gate A3C. When the output of counter A4 reaches ten, transistor Q66 conducts and turns on DS2. The function of gate A3B and transistor Q65 is to clamp the output of the VCO when counter A4 has a count of eleven during the first period of the measurement cycle (first digit) or a count of nine during any subsequent periods. The polarity sign indicator, V5, is operated by transistors Q81 and Q82, which are driven by the polarity sensing circuit.

3-51. Power Supply

3-52. Power for the Model 8100A is supplied either by the ac power line via power transformer T101 or by the internal rechargeable battery pack, BT1 (Option-01). The secondary of T101 is tapped for two output voltages. The higher voltage is rectified by diodes CR32 and CR33 and is used to charge the batteries through ballast lamp DS11. The ballast lamp regulates or limits battery charging current to ensure a safe level of charging current regardless of battery condition. The lower voltage is rectified by diodes CR1 and CR2 to provide operating voltage for the instrument. The voltage at filter capacitor C1 is always greater than the battery voltage during power line operation; therefore, diode CR34 is back biased, thereby preventing drain from the batteries during power line operation. The rectified power line voltage is fed through fuse F2 to a

series regulator consisting of pass element Q1, driver Q2, and voltage amplifier Q3. This regulator provides −18 volts to operate the inverter and supply negative power supply voltages for the instrument. Meter M1 is placed across the pass element to provide an indication of battery condition.

3-53. The inverter is a transformer-coupled multivibrator consisting of driver transistors Q4 and Q5, transformer T102, and RC timing network C4, R6, and R7. The inverter derives its operating voltage from the −18 volt supply and is energized as soon as instrument power is applied. It operates at a frequency of approximately 250 Hz. The square wave at the primary of T102 is rectified by diodes CR5 and CR6 to provide positive voltage to operate the +15 volt regulator. The +15 volt regulator consists of pass element Q6, driver Q7, and voltage amplifier Q8. The +15 volt regulator obtains its reference from the zener diode portion of reference amplifier Q11. In addition to supplying positive power supply voltages to operate the instrument, the +15 volt regulator also supplies the input for the +7 volt reference supply.

3-54. The +7 volt reference supply consists of compound emitter follower Q9, Q10, which is driven by reference amplifier Q11. The reference voltage is set precisely by R23 (−DC CAL control). Since the +7 volt reference supply must sink as well as supply current, resistor R181 is shunted across the output to draw a constant 2 milliamps from the supply. Also, diode CR10 is placed across the output of the supply to prevent current reversal during overload in the KΩ or 10 MΩ modes.

3-55. A high voltage tap in the primary of T102 supplies voltage to a half-wave voltage doubler consisting of diode CR3 and capacitor C6. The 200 volt output of the doubler is used to operate the readout tubes, V1 through V4; the overrange indicator, DS2; and the polarity indicator, V5. Filtered dc voltage for operation of the integrated circuit logic is provided by diodes CR7 and CR8 and capacitor C44 in the secondary of T102.

Section 4
Maintenance

4-1. INTRODUCTION

4-2. This section contains information and instructions concerning preventive and corrective maintenance for the Model 8100A Digital Multimeter. Preventive maintenance consists primarily of cleaning the instrument and should be performed as often as operating conditions require. Corrective maintenance consists of troubleshooting, calibration, and performance test procedures, which are designed to aid in maintaining instrument operation within specifications. Section 3 of the instruction manual is an important supplement to the troubleshooting section, since a thorough knowledge of instrument theory is indispensable in troubleshooting.

4-3. A calibration interval of 90 days is recommended to ensure instrument operation within the 90-day specifications stated in Section I of the manual and a calibration interval of 30 days is recommended for operation within the 30-day specifications. The performance of the instrument should be verified in accordance with the performance tests in paragraph 4-19 before calibration is attempted. An instrument that meets all of the requirements of the performance tests need not be calibrated. An instrument that does not meet the requirements of the performance tests will require troubleshooting or calibration.

4-4. SERVICE INFORMATION

4-5. Each instrument manufactured by the John Fluke Manufacturing Company is warranted for a period of one year upon delivery to the original purchaser. Complete warranty information is contained in the Warranty page located at the rear of the manual. Factory authorized calibration and repair service for all Fluke Instruments is available at various world wide locations. A complete list of factory authorized service centers is located at the rear of the manual. If requested, an estimate will be provided to the customer before any repair work is begun on instruments which are beyond the warranty period.

4-6. TEST EQUIPMENT

4-7. The equipment recommended for performance testing, troubleshooting, and calibration of the Model 8100A, together with the minimum specifications required in each case, is listed in Table 4-1. If the recommended equipment is not available, other equipment which meets the required specifications may be used.

4-8. GENERAL MAINTENANCE

4-9. Access/Disassembly

4-10. All circuit board components except indicator tubes are accessible after removing the covers and guards. The indicator tube access procedure is given in paragraph 4-15. The following procedure may be used to gain access to all components except tubes.

a. Remove the top and bottom covers and the narrow trim strips just above and below the readout tubes.

EQUIPMENT NOMENCLATURE	SPECIFICATIONS REQUIRED	RECOMMENDED EQUIPMENT
DC Voltage Source	Range: 0 to ±1000 vdc Accuracy: ±0.005% of setting Stability: ±0.0005% of setting or 20 uv (whichever is greater).	Fluke Model 343A DC Voltage Calibrator
AC Voltage Source	Voltage Range: 0 to 100 vrms Voltage Accuracy: ±0.05% of setting (50 Hz to 10 kHz) ±0.1% of setting (10 kHz to 20 kHz) Voltage Stability: ±0.002% of setting per 24 hours. Frequency Range: 1 kHz to 20 kHz	Hewlett Packard Model 745A AC Calibrator
Precision Resistors 1.0000k 10.000k 100.00k 1000.0k	Accuracy: ±0.01% Power Capability: 2 mw minimum	General Radio Type 1440 Standard Resistor
Precision Resistor 10 MΩ	Accuracy: ±0.01%	
Autotransformer	Voltage: 0 to 130 vac Current: 3 amp	General Radio Model W5MT3AW Metered Variac
Wattmeter	Power: 0 to 200w	
Multimeter	Accuracy: ±2% dc volts ±3% ac volts Input Impedance: 11 MΩ dc 1 MΩ ac	Fluke Model 853A Differential Multimeter
High Impedance or Differential DC Voltmeter	Range: 0 to ±1000 vdc Accuracy: ±0.02% of input Input Impedance: 10^7 ohms minimum	Fluke Model 8300A Digital Voltmeter
Oscilloscope	Vertical Sensitivity: 0.1v/cm minimum Sweep Speed: 0.5 usec/cm minimum Probe: High Impedance (10 MΩ)	Tektronix Type 545A Oscilloscope with Type 1A1 Dual Trace Plug-In

Table 4-1. TEST AND CALIBRATION EQUIPMENT

b. Remove the top guard (1) by disconnecting the spade-lug guard-connecting wire located on the right rear of the guard, (2) by disconnecting the two battery leads at the printed circuit board (if battery option is installed), and (3) by removing the four guard mounting screws, which are located on the instrument side rails.

CAUTION!

Do not remove the six screws located on the top of the guard. These screws are for battery pack access only and should not be removed until the guard is completely removed from the instrument.

c. Remove the bottom guard by removing the four screws which hold it in place.

4-11. Fuse Replacement

4-12. Instrument fuses are located inside the instrument. The line fuse is located in a fuse block attached to the inside of the rear panel and is accessible from the bottom of the instrument after removing the bottom cover. The power supply fuse is mounted in fuse clips, which are attached to the printed circuit board near the power transformer. This fuse is accessible from the top of the instrument after removing the top cover. Correct values for the fuses are as follows:

REFERENCE DESIGNATION	FUNCTION	RATING
F1	Line fuse	115 volt operation: 1/8 ampere slow-blow 230 volt operation: 1/16 ampere slow-blow
F2	Power supply fuse	AGC 1/4 ampere

4-13. 115/230 Volt Conversion

4-14. The Model 8100A may be operated from either 115 or 230 volt ac power, depending upon the connection of the power transformer (T101) primary winding. Convert the instrument from one type of power line operation to the other by the following procedure:

a. Disconnect the instrument from the power line.

b. Place the 115/230 slide switch, located at the rear of the instrument, in the position which corresponds to the desired operating voltage.

c. Ensure that the proper line fuse for the selected voltage is installed (paragraph 4-11) before operating the instrument.

4-15. Lamp and Tube Replacement

4-16. The ballast lamp, DS11, is soldered in place on the circuit board and is located at the rear of the instrument near the power transformer. It is accessible after removing the top and bottom covers. The readout tubes, V1 through V4, and the polarity indicator, V5, are mounted in tube sockets and are located inside the molded black tube cover at the front of the circuit board. To gain access to the tubes, proceed as follows:

a. Remove the top and bottom covers and the narrow trim strips just above and below the readout tubes.

b. Remove the tilt-down bail assembly.

c. Remove the small nut and washer located just to the right of the INPUT terminals (viewed from the top) on the inside of the front panel.

d. Remove the eight screws (four on either side) which hold the front panel assembly to the side rails.

e. Pull the front panel assembly forward to the extent permitted by the INPUT terminal wiring.

f. Remove the molded tube cover by removing the two nuts located beneath the tube cover on the underside of the circuit board.

4-17. Switch Maintenance

4-18. The following procedures cover service and replacement of the pushbutton switches.

4-19. GENERAL

a. Remove the covers, trim strips, and guard. See paragraph 4-9 for guard removal instructions.

b. Set all switches to the nondepressed position.

c. If switch contacts are to be serviced, locate which of the 19 switch modules is to be dis-

assembled (Figure 4-1) and refer to the corresponding disassembly procedure, paragraphs 4-20 through 4-22.

d. If a complete switch module is to be replaced, refer to paragraphs 4-23 and 4-24.

e. To remove pushbuttons, pry the button off by applying pressure to the rear of the button from the inside of the front panel. Note that on some instruments buttons are glued on the switch shaft. When replacing buttons, use a small amount of contact cement. Apply glue to shaft only.

4-20. PROCEDURE NO. 1 - DISASSEMBLY OF REAR SWITCHES (Figure 4-2)

a. Remove the extension shaft associated with the switch by depressing the switch shaft and removing the extension shaft as shown in Detail A, Figure 4-2.

b. Remove the retaining clip and spring from the switch shaft.

NOTE!
The retaining clip may be re-installed on the switch shaft from either the board side or from the opposite side (cover side). Either method is satisfactory.

c. Remove the switch shaft by pushing it slowly out the back of the switch module. The moveable switch contacts will spring out of their slots in the shaft as this is done (see Detail B, Figure 4-2).

CAUTION!
Under no circumstances should attempts be made to re-form or add tension to the contacts by bending them.

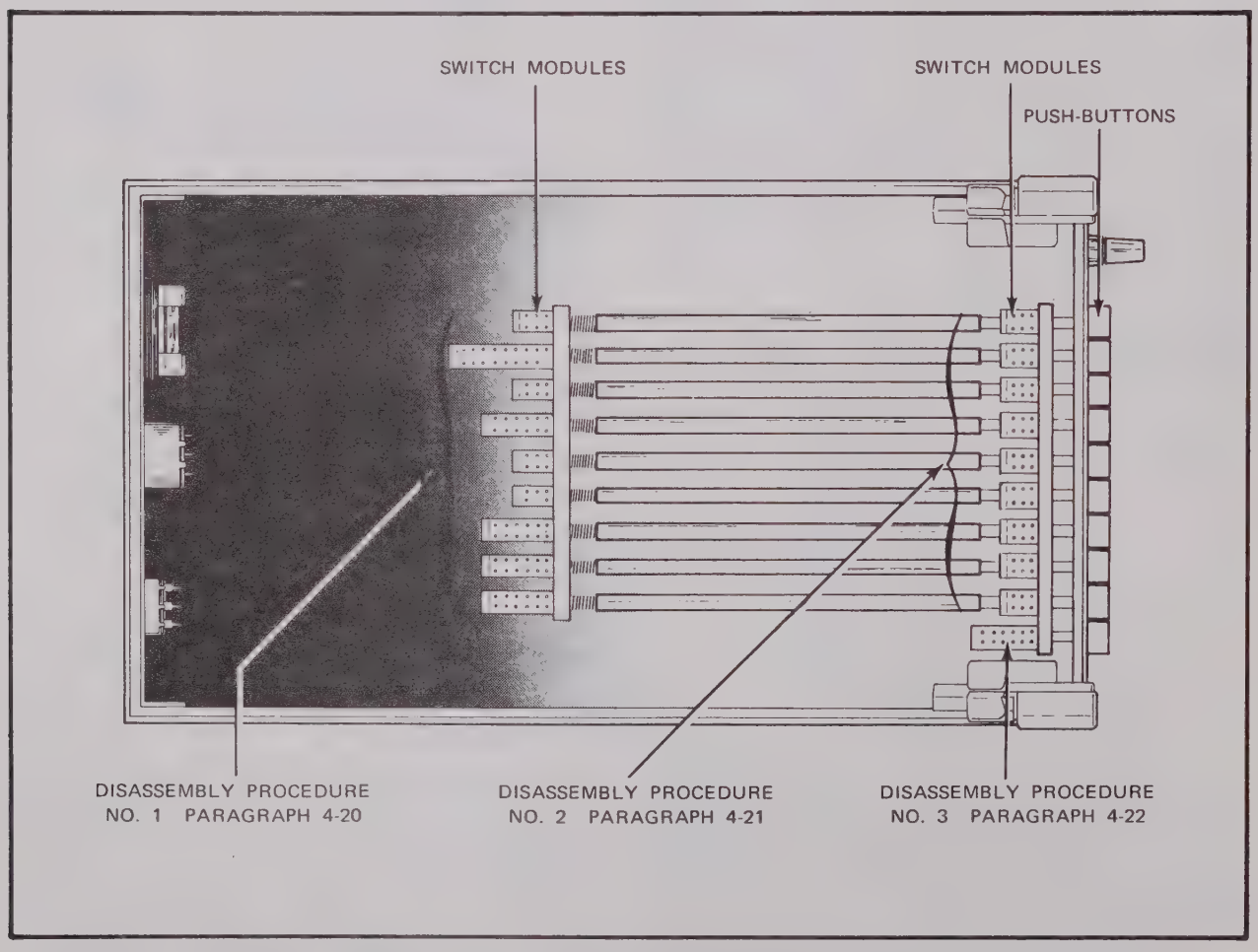


Figure 4-1. SWITCH MODULE LAYOUT AND DISASSEMBLY PROCEDURES

d. Inspect the switch contacts for contamination and, if necessary, clean them with a cotton swab saturated in alcohol. After cleaning, the contacts must be re-coated with a thin coat of grease: Use RYKON 2EP grease (American Oil Co.) or equivalent.

e. Assemble the switch by reversing the foregoing procedure. Exercise caution to ensure the contacts are not deformed during assembly.

4-21. PROCEDURE NO. 2 - DISASSEMBLY OF FRONT SWITCHES (EXCEPT POWER SWITCH)

a. Remove the extension shaft associated with the switch by depressing the switch shaft and removing the extension shaft as shown in Detail A, Figure 4-2.

b. Remove the pushbutton from the switch.

c. Remove the switch shaft by sliding the latch bar to the side and pushing the shaft slowly out the back of the switch module (see Detail A, Figure 4-3). Use a pointed tool to move the latch bar. The latch bar is conveniently actuated from the shaft opening at an adjacent switch, in which case the pushbutton will have to be removed from the adjacent switch shaft also. The moveable contacts will spring out of their slots in the shaft as

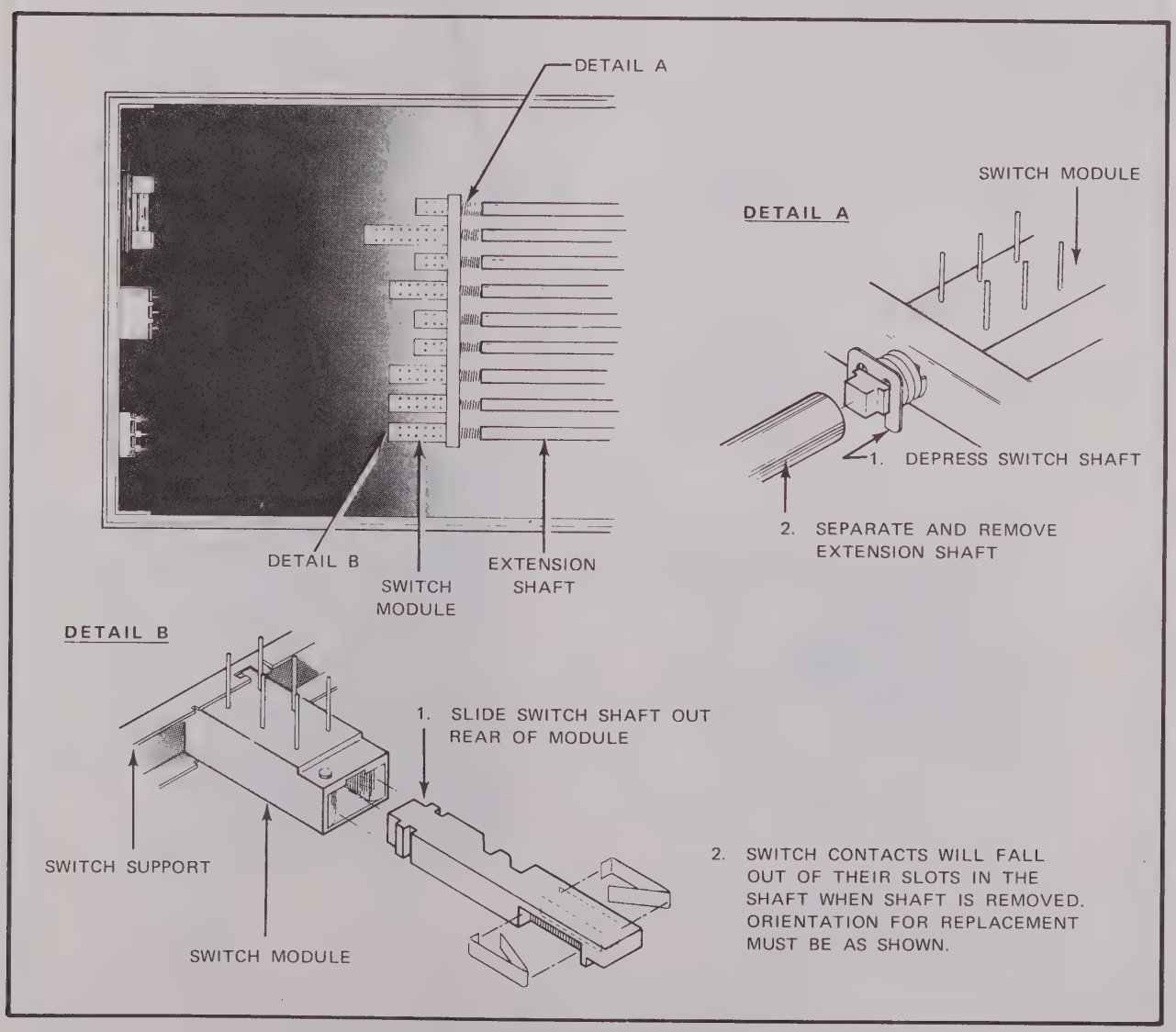

DETAIL A
DETAIL B
SWITCH MODULE
EXTENSION SHAFT
SWITCH MODULE
DETAIL A
1. DEPRESS SWITCH SHAFT
2. SEPARATE AND REMOVE EXTENSION SHAFT
DETAIL B
1. SLIDE SWITCH SHAFT OUT REAR OF MODULE
SWITCH SUPPORT
SWITCH MODULE
2. SWITCH CONTACTS WILL FALL OUT OF THEIR SLOTS IN THE SHAFT WHEN SHAFT IS REMOVED. ORIENTATION FOR REPLACEMENT MUST BE AS SHOWN.

Figure 4-2. DISASSEMBLY OF REAR SWITCH MODULES

the switch shaft is removed (see Detail B, Figure 4-2).

CAUTION!

Under no circumstances should attempts be made to re-form or add tension to the contacts by bending them.

d. Inspect the switch contacts for contamination and, if necessary, clean them with a cotton swab saturated in alcohol. After cleaning, the contacts must be re-coated with a thin coat of grease: Use RYKON 2EP grease or equivalent.

e. Assemble the switch by reversing the foregoing procedure. Exercise caution to ensure the contacts are not deformed during assembly.

NOTE!

The latch bar will have to be slid to the side, as in step (c), to replace the switch shaft.

4-22. PROCEDURE NO. 3 - DISASSEMBLY OF POWER SWITCH (Figure 4-3)

a. Remove the pushbutton from the switch.

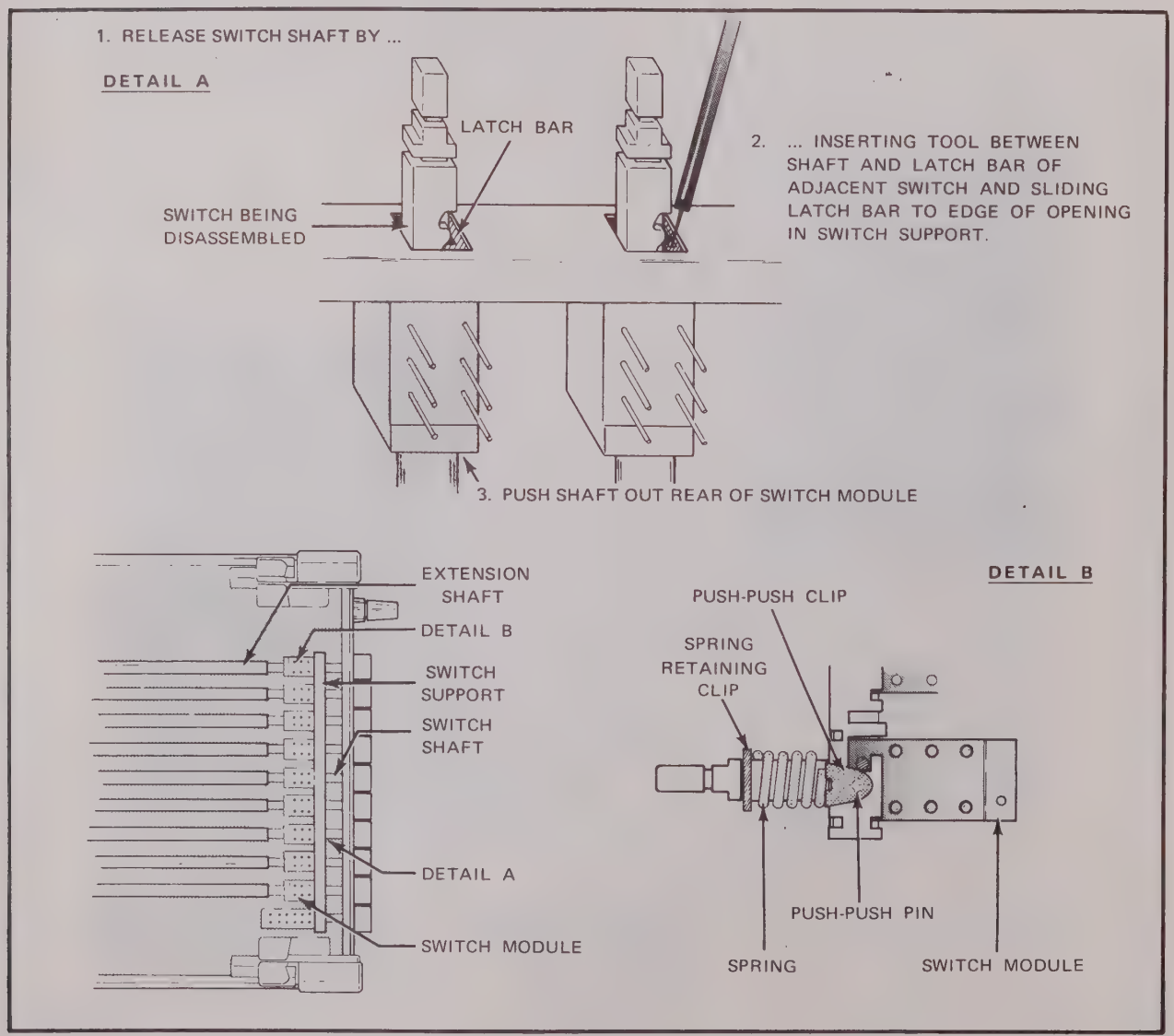


Figure 4-3. DISASSEMBLY OF FRONT SWITCH MODULES

b. Remove the spring retaining clip, the spring, the push-push clip, and the push-push pin (see Detail B Figure 4-3).

c. Remove the switch shaft by pushing it slowly out the back of the switch module. The moveable switch contacts will spring out of their slots in the shaft as this is done (see Detail B, Figure 4-2).

CAUTION!

Under no circumstances should attempts be made to re-form or add tension to the contacts by bending them.

d. Inspect the switch contacts for contamination and, if necessary, clean them with a cotton swab saturated in alcohol. After cleaning, the contacts must be re-coated with a thin coat of grease: Use RYKON 2EP or equivalent.

e. Assemble the switch by reversing the foregoing procedure. Exercise caution to ensure the contacts are not deformed during assembly.

4-23. SWITCH MODULE REPLACEMENT – REAR SWITCHES (Figure 4-4).

a. Unsolder all wires and components connected to terminals of switch modules.

b. Desolder entire rear switch set by removing the solder from all switch pins on component side of main PCB.

CAUTION!

Use a desoldering tool and exercise extreme caution to avoid lifting land patterns or otherwise damaging the PCB.

c. Remove switch set from PCB.

d. Bend up the locking tab (on switch support) which holds the defective switch module in position. Remove and descard defective switch module. See Detail A, Figure 4-4.

e. Install new switch module by reversing foregoing procedure.

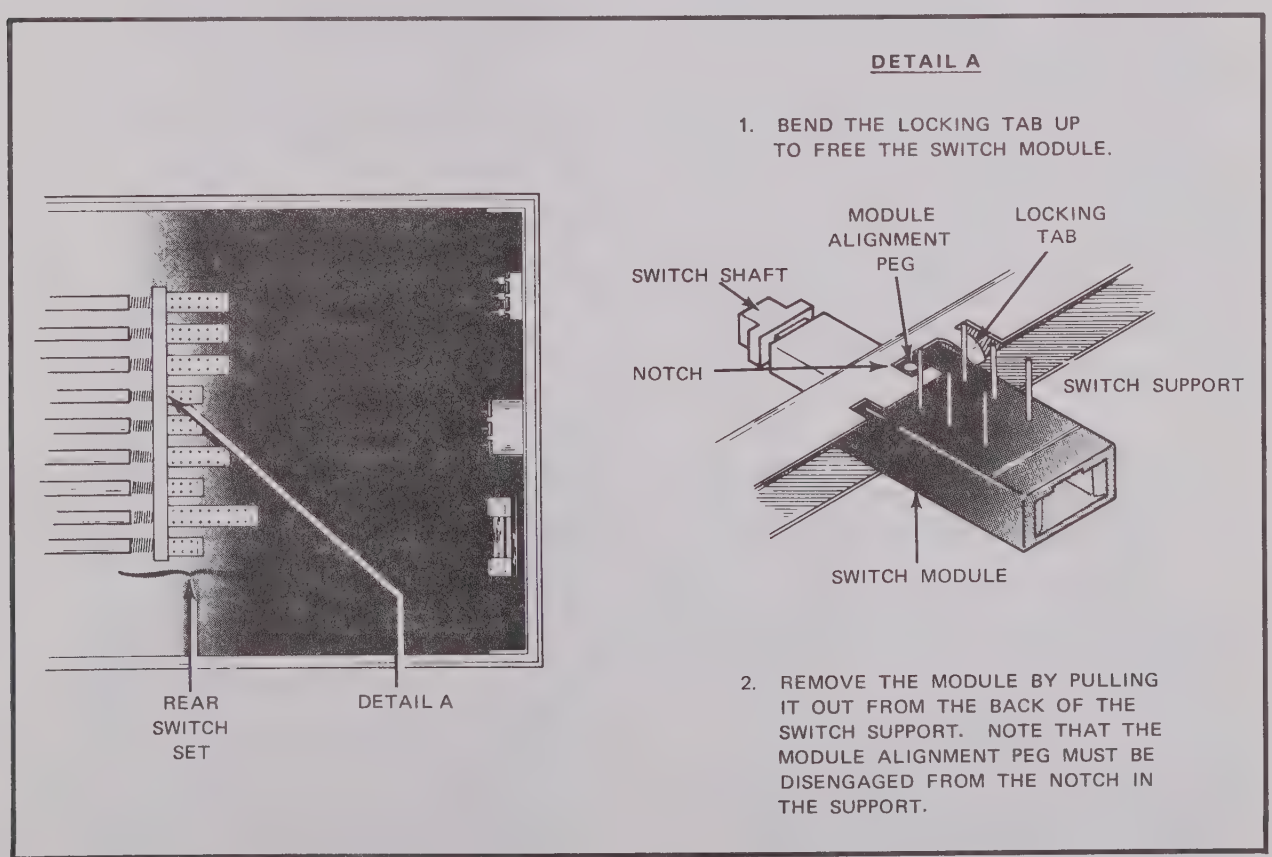

REAR SWITCH SET
DETAIL A
DETAIL A
1. BEND THE LOCKING TAB UP TO FREE THE SWITCH MODULE.
MODULE ALIGNMENT PEG
LOCKING TAB
SWITCH SHAFT
NOTCH
SWITCH SUPPORT
SWITCH MODULE
2. REMOVE THE MODULE BY PULLING IT OUT FROM THE BACK OF THE SWITCH SUPPORT. NOTE THAT THE MODULE ALIGNMENT PEG MUST BE DISENGAGED FROM THE NOTCH IN THE SUPPORT.

Figure 4-4. MODULE REPLACEMENT – REAR SWITCH SET

4-24. SWITCH MODULE REPLACEMENT – FRONT SWITCHES (Figure 4-4).

a. Remove all front panel pushbuttons.

b. Unsolder all wires connected to terminals of switch modules.

c. Desolder entire front switch set by removing the solder from all switch pins on component side of main PCB.

CAUTION!

Use a desoldering tool and exercise extreme caution to avoid lifting land patterns or otherwise damaging PCB.

d. Remove switch set from PCB.

e. Remove defective switch module shaft and contacts according to the procedure given in paragraphs 4-21 and 4-22.

f. Bend up locking tab (on switch support) which holds defective switch module in position. Remove and discard defective switch module. See Detail A, Figure 4-4.

g. Install new switch module by reversing foregoing procedure.

4-25. Cleaning

4-26. The instrument should be cleaned periodically to remove dust, grease, and other contamination. The following procedure should be adhered to when cleaning the instrument:

a. Remove loose contamination with low-pressure, clean, dry air. Pay particular attention to the front panel binding posts and binding post wiring.

b. The front panel and exterior surfaces may be cleaned with anhydrous ethyl alcohol or a soft cloth dampened in a mild solution of detergent and water.

CAUTION!

Do not use aromatic hydrocarbons or chlorinated solvents on the front panel, because they will react with the Lexan binding posts.

4-27. PERFORMANCE TESTS

4-28. The following tests are intended for use in performance testing of the 8100A. The tests compare the instrument performance to the accuracy specifications and are especially suited to acceptance testing of new instruments. Tests should be conducted under the following conditions: ambient temperature 25°C ±5°C, relative humidity less than 70%.

NOTE!

Tolerances and test limits for performance tests are derived from the 90-day instrument specifications.

4-29. DC Voltage Test

4-30. In the following procedure, dc voltages are applied to the instrument at 100% of full scale on the 10, 100, and 1000 volt ranges and at 10% and 100% of full-scale on the 1 volt range. A dc voltage source equivalent to the one shown in Table 4-1 is required for this test.

a. Connect the 8100A to the ac line.

b. Set the 8100A controls as follows:

POWER	ON
Function	VDC
RANGE	As Required
FILTER	ON

c. Apply each of the input voltages shown in Table 4-2, in turn, to the INPUT terminals of the 8100A. The 8100A readout should be as indicated.

Table 4-2. DC VOLTAGE TEST REQUIREMENTS.

INPUT (VOLTS DC)	MODEL 8100A	
	RANGE	READOUT LIMITS
+1000	1000	+999.7 to +1000.3
+100	100	+99.97 to 100.03
+10	10	+9.997 to 10.003
+1.0001	1	+.9998 to +1.0004
+0.0999	1	+.0998 to +.1000
+0.1000	1	+.0999 to +.1001

d. Repeat step (c) with negative input voltages. The 8100A readout should be the same as for positive

inputs, except that the polarity indication should be negative (–).

4-31. AC Voltage Test

4-32. In this test, full-scale voltages are applied to the instrument input at 100% of full scale on the 1, 10, and 100 volt ranges and 10% of full scale on the 1000 volt range. The 1 and 10 volt ranges are checked at 1 kHz, 10 kHz, and 20 kHz and the 100 and 1000 volt ranges are checked at 1 kHz only. An ac voltage source equivalent to the one shown in Table 4-1 is required for this test.

a. Connect the 8100A to the ac line.

b. Set the 8100A controls as follows:

POWER	ON
Function	VAC
RANGE	As Required
FILTER	ON

c. Apply the ac test signals shown in Table 4-3 to the 8100A INPUT terminals. The readout should be as indicated.

4-33. Ohms Test.

4-34. The ohmmeter section of the instrument is checked by measuring standard resistors, whose values correspond to full scale readings on each ohms range. Standard resistors equivalent to those given in Table 4-1 should be used.

a. Connect the 8100A to the ac line.

b. Set the 8100A controls as follows:

POWER	ON
Function	As required
RANGE	As required
FILTER	ON

c. Connect each of the standard resistors shown in Table 4-4, in turn, to the INPUT terminals of the 8100A (use short, low-resistance connecting leads). RANGE and function switches as required. 0A readout should be as indicated.

4-35. TROUBLESHOOTING

4-36. This section contains information selected to assist in troubleshooting the 8100A. Before attempting to troubleshoot the instrument, however, it should be verified that the trouble is actually in the instrument and is not caused by faulty external equipments or improper control settings. The performance tests (paragraph 4-29) are suggested as a first step in troubleshooting, since they may help to localize the trouble to a particular section of the instrument. If they fail to localize the trouble, the following individual tests may be helpful. Figure 4-5 shows location of circuit areas and test points on the PCB and Figure 4-6 shows pin connections for integrated circuits used in the instrument.

Table 4-3. AC VOLTAGE TEST REQUIREMENTS.

INPUT		MODEL 8100A	
FREQUENCY (KHZ)	RMS VOLTS	RANGE	READOUT LIMITS
1	1	1	.9975 to 1.0025
1	10	10	9.975 to 10.025
1	100	100	99.75 to 100.25
1	100	1000	099.3 to 100.7
10	1	1	.9975 to 1.0025
10	1	1	.9975 to 10.025
20	1	1	.9940 to 1.0060
20	10	10	9.940 to 10.060

Table 4-4. OHMS TEST REQUIREMENTS.

STANDARD	MODEL 8100A		
RESISTANCE	FUNCTION	RANGE	READOUT LIMITS
1.0000k	KΩ	1	.9994 to 1.0006
10.000k	KΩ	10	9.994 to 10.006
100.00k	KΩ	100	99.94 to 100.06
1000.0k	KΩ	1000	999.4 to 1000.6
10 MΩ	10 MΩ	– –	9.989 to 10.011

4-37. Power Consumption

4-38. This test verifies proper power consumption by the instrument.

a. Connect the 8100A through an ammeter to the ac line.

b. Press the POWER-ON switch and observe the reading on the ammeter. With only the POWER-ON switch depressed, the ammeter should indicate 42 ±4 milliamps for an instrument without batteries or 80 ±10 milliamps for an instrument with batteries.

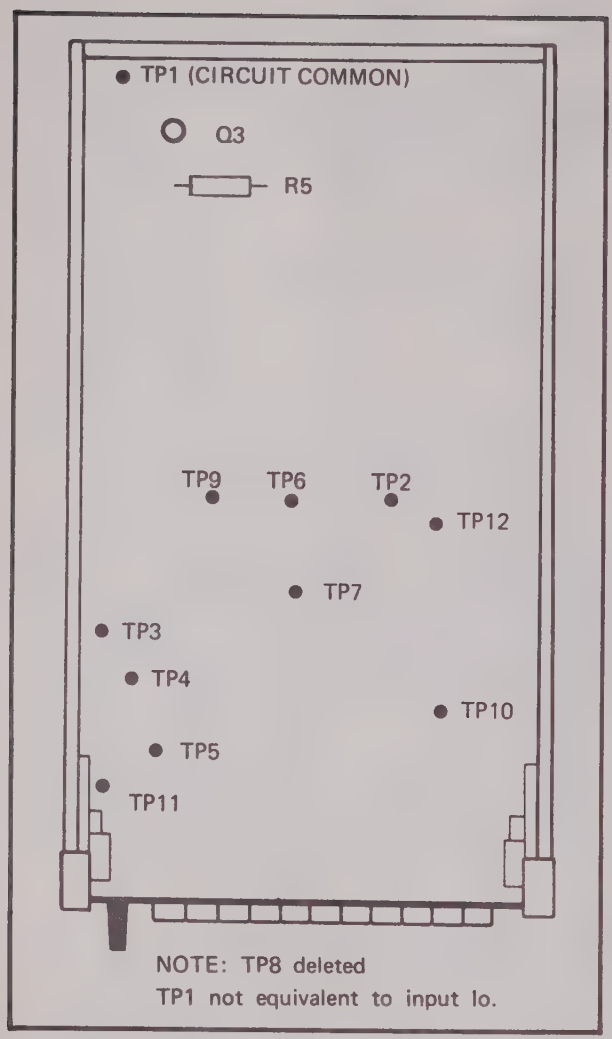


Figure 4-5. LOCATION OF CIRCUIT AREAS AND TEST POINTS ON PCB.

4-39. Power Supply

4-40. Supply levels are referenced in such manner that unless all output levels are correct, most levels will be incorrect. This occurs because the −18 volt aupply is referenced to the +15 volt supply, which is in turn referenced to the +7 volt supply. If the −18 volt supply is high, the +15 volt and the +200 volt supplies will also be high. If the −18 volt, +15 volt, or +7 volt supply is low, all supply output voltages will be low.

4-41. To measure the output voltages, use a voltmeter accurate to at least ±0.025% and proceed as follows:

a. Set the function, RANGE, and FILTER switches to any position.

b. Connect the voltmeter common to 8100A common (TP1) and measure the voltages shown in Table 4-5. Voltages should be as indicated.

Table 4-5. POWER SUPPLY VOLTAGE REQUIREMENTS

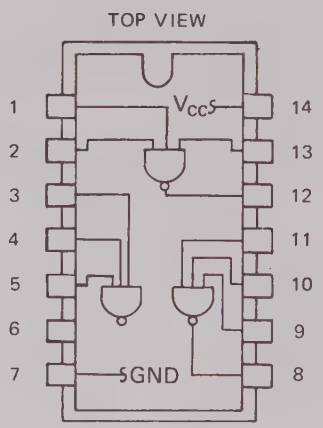
VOLTAGE TEST POINT	NOMINAL	LIMITS
Either terminal of fuse F2	−23 −24	Battery Operation: −19 to −24 Line Operation: −24 Minimum
Collector (case of Q1)	−18	−17.5 to −18.5
+Terminal of C5	+17	+16.5 to +17.5
+Terminal of C7	+15	+14.5 to +15.5
+Terminal of C8	+7	+6.993 to +7.007
+Terminal of C44	+5	+4.5 to +5.5
+Terminal of C65	+200	+185 to +205

4-42. The following procedures can be used to isolate which supply output is low; either procedure makes the −18 volt supply independent of the other supplies for its reference. Disconnect the +15 volt end of resistor R5 and connect it to a stable external +15 volt source, or disconnect R5 from the base of Q3 and connect a 1330Ω ±1% resistor from the base of Q3 to signal ground. Location of R5 and Q3 is shown in Figure 4-5.

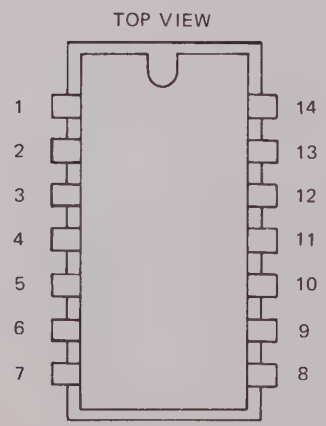
Bottom View

1. Compensation
2. Input (–)
3. Input (+)
4. V (+) (connected to case)
5. Balance
6. Output
7. V (+)
8. Compensation

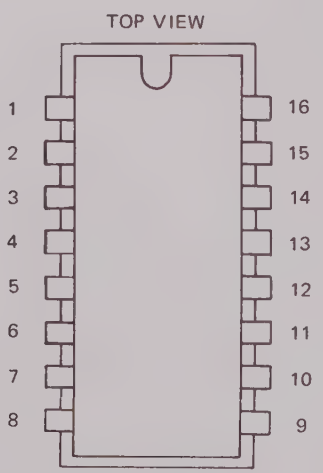
Amplifier A1 (Buffer) and A2 (A-to-D Converter)



3-Input NAND Gate - A1



Divide-by-Sixteen Binary Counter - A4



Decoder Driver - A5

Figure 4-6. INTEGRATED CIRCUIT PIN ORIENTATION

4-43. Buffer

4-44. In 1 volt dc range, the voltage between INPUT LO and signal ground (TP1) should very nearly equal the input voltage between INPUT HI and LO. At full range (–1.1999 or +1.1999 volts) the deviation should be less than 60 microvolts; at zero volts input, deviation should be less than 10 microvolts.

4-45. When measuring buffer performance, it should be noted that the INPUT LO terminal is not 8100A signal ground, as shown in Figure 4-7. This circuit may become

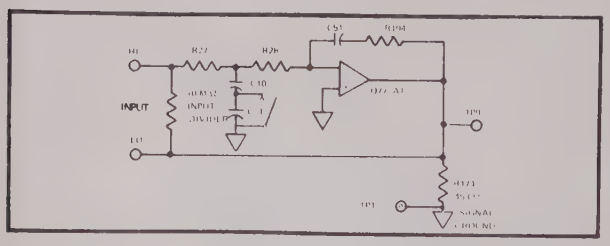


Figure 4-7. INPUT BUFFER CONFIGURATION - 1 VDC RANGE.

unstable and oscillate if a large capacitance (500pf or more) is placed across R174. To avoid this problem, it is recommended that test equipment ground be connected to INPUT LO instead of TP1 when the 8100A is measuring dc volts. In ac voltage mode, INPUT LO and signal common are equivalent.

4-46. To check the buffer in both ac and dc voltage modes, proceed as follows:

a. Set the 8100A controls as follows:

POWER	ON
Function	VDC
RANGE	1
FILTER	ON

b. Connect +1.0000 volts dc to the INPUT terminals.

c. Connect a high impedance voltmeter between instrument common (TP1) and TP9. The voltmeter should indicate −1.0000 ±0.0003 volts dc.

d. Disconnect the voltmeter high lead from TP9 and connect it to the positive (+) terminal of capacitor C18.

e. Press the VAC function switch and connect a 1.0000 volt, 1 kHz signal to the instrument INPUT terminals. The voltmeter should indicate 1.0000 ±0.0025 volts dc. If the A-to-D converter and display sections of the 8100A are working, the 8100A readout should correspond to the voltmeter indication.

4-47. A-to-D Converter

4-48. It is convenient to use VAC mode to check the A-to-D converter and display circuitry, because in this mode the INPUT LO terminal and 8100A circuit common are equivalent, as shown in Figure 4-8. The ac input signal is

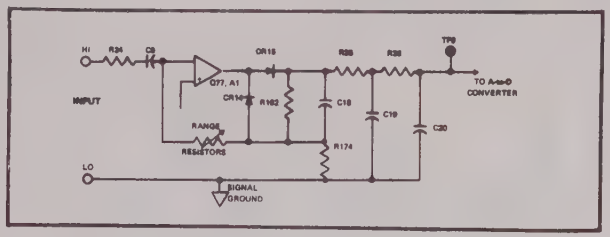


Figure 4-8. BUFFER CIRCUIT ARRANGEMENT - VAC MODE.

connected between INPUT HI and LO. If buffer problems are suspected, however, the buffer can be bypassed by connecting a low impedance (<<820k) dc source of zero to +1.1999 volts dc between INPUT LO and TP9, (Figure 4-9). The resulting readout should correspond to the A-to-D converter input.

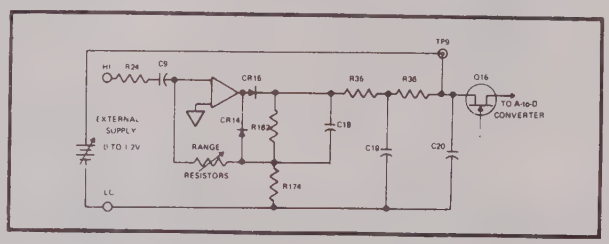


Figure 4-9. BUFFER, VAC MODE, SHUNTED BY EXTERNAL DC SIGNAL

4-49. 300 MS Sample Rate Suppression

4-50. The A-to-D converter samples the input at a fixed rate of once each 300 milliseconds. The sampled reading is then stored on capacitors C30 through C33 and is read out of storage repeatedly until the next sample is taken. The storage mode can be eliminated for test purposes by installing a jumper between TP4 and TP5. This will force the A-to-D converter to sample the input during period 1 of every measurement cycle, i.e., once each 20 milliseconds.

4-51. Auto-Zero Suppression

4-52. Amplifier A2 in the A-to-D converter is zeroed automatically by circuitry consisting of Q58, R180, and C37. Some failures in the converter may cause the auto-zero circuit to overcomponsate and mask the trouble. To disable the auto-zero circuit, connect a jumper between TP6 and TP7. A few digits offset will be present in the readout and it will stay at zero for several digits of input on one polarity, but when the input is raised the output should follow properly.

4-53. Ring Counter

4-54. The signal at TP3 (Figures 4-10 and 4-11) is convenient for evaluation of the ring counter. The signals at the collectors of Q20 through Q24 are identical, but are displaced in time.

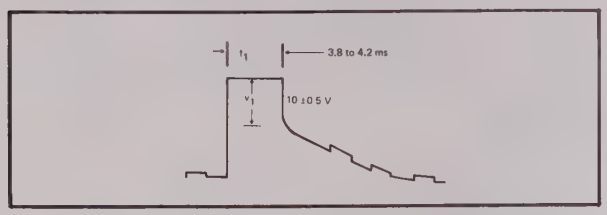


Figure 4-10. TP3 - RING COUNTER WAVEFORM.

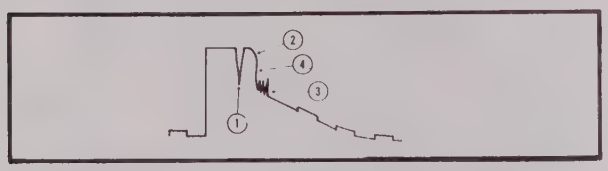


Figure 4-11. TP3 - RING COUNTER MARGINAL WAVEFORM.

a. In the waveform shown in Figure 4-10, t_1 should be 3.8 to 4.2 milliseconds. If t_1 is not correct, check clock signal duration. It should be 4 ±0.2 milliseconds duration.

b. The trailing edge of the signal at TP3 should be a 10 ±0.5 volt step. Factors which determine this step amplitude are repetition rate and the values of C26 and R56.

c. A marginal waveform is shown in Figure 4-11 and described as follows:

1. Spike in center indicates near minimum pulse-repetition rate. Sync bias level, controlled by R61, and synchronizing signal amplitude affect center spike.

2. Trailing edge droop is mainly a function of Q19 gain: H_{FE} should be greater than 100 at 1 milliamp, 0.5 volts. Droop occurs at maximum pulse repetition rate.

3. Spikes following the pulse occur if the ring counter is near an oscillation condition: Check capacitor C57.

4. Trailing edge switching time should be between 2 and 15 microseconds. Switching time is a function of the transistor and the synchronizing signal. Fall times as long as 40 microseconds have been observed when sync bias is incorrect.

d. The ring is subject to failure if the output lines are loaded by a faulty transistor, such as Q65, Q30, Q34, or any other device connected to the ring output lines. This type of failure causes the ring to oscillate at random intervals. To isolate ring problems, connect TP11 to the +15 volt supply and check that each output line is between −17 and −18 volts. Remove the +15 volt connection from TP11 and check that each collector saturates to within −0.3 volts of signal ground when the corresponding transistor turns on. Test jumpers are provided at ring positions 1, 2, 3 and 4, and can be cut to isolate loading problems in the ring.

e. The ring counter synchronizing signal, TP11, should appear as shown in Figure 4-12.

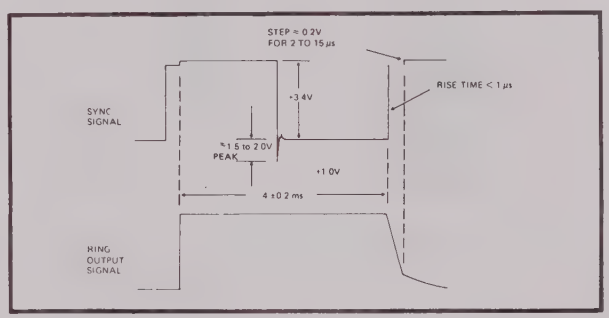


Figure 4-12. RING COUNTER - SYNC SIGNAL.

4-55. Measure/Store Multivibrator

4-56. Waveforms associated with the measure/store multivibrator are shown in Figure 4-13.

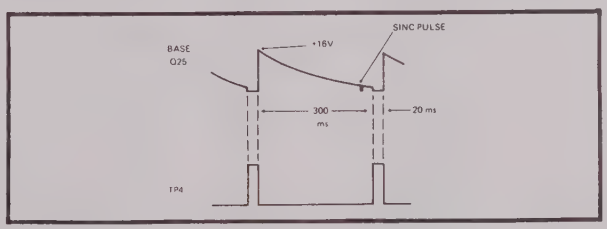


Figure 4-13. MULTIVIBRATOR WAVEFORMS.

4-57. Linearity

a. Set the 8100A controls as follows:

Function	VDC
RANGE	1
FILTER	OFF

b. Apply each of the following voltages, in turn, to the INPUT terminals. The instrument readout should be as indicated.

NOTE!

The readout limits apply only to instruments that have just been calibrated.

INPUT (Volts DC)	MODEL 8100A READOUT LIMITS
−1.1999	−1.1998 to −1.2000
−1.0999	−1.0998 to −1.1000
−0.9999	− .9998 to −1.0000
−0.8999	− .8998 to − .9000
−0.7999	− .7998 to − .8000
−0.6999	− .6998 to − .7000
−0.5999	− .5998 to − .6000
−0.4999	− .4998 to − .5000
−0.3999	− .3998 to − .4000
−0.2999	− .2998 to − .3000
−0.1999	− .1998 to − .2000
−0.0999	− .0998 to − .1000

c. If voltages are not correct, the ladder resistors should be checked for proper value.

4-58. Waveforms

4-59. In the following test, a dc test voltage is applied to the instrument and the main signal waveforms are examined, using an oscilloscope.

a. Set the 8100A controls as follows:

POWER	ON
Function	VDC
RANGE	1
FILTER	ON

b. Apply any stable dc voltage, within the range of the instrument, to the INPUT terminals.

c. Connect the oscilloscope between each of the test points shown in Table 4-6 and instrument common (TP1 or TP5), using ac coupling; set the oscilloscope controls as shown. A stylized version of the desired signal is shown on the main schematic diagram. Note that the A-to-D converter amplifier and VCO waveforms will vary, depending on input voltage value.

Table 4-6. SIGNAL LOCATIONS AND OSCILLOSCOPE SETTINGS FOR WAVEFORM CHECK.

	TEST POINT	OSCILLOSCOPE	
		VERTICAL SENSITIVITY	SWEEP SPEED
Clock	Junction of R53 and R54	1v/cm	0.5 ms/cm
Ring Counter	TP3	10v/cm	5 ms/cm
A-to-D Converter* Amplifier Output	TP2	5v/cm	2 ms/cm
VCO	Collector of Q60	2v/cm	2 ms/cm
Q35 Gate	Gate of Q35	10v/cm	5 ms/cm
Counter Reset	Pin 2 of A4	2v/cm	1 ms/cm

* Waveform will be slightly different every fifteenth reading.

4-60. CALIBRATION

4-61. Equipment required for calibration is given in Table 4-1. Calibration should be performed under the following test conditions; ambient temperature 25°C +5°C, realtive humidity less than 70%. Adjustment locations are silk-screened on the bottom guard cover.

4-62. Preliminary

a. Connect the 8100A to an autotransformer adjusted for 115 volts.

b. Set 8100A FUNCTION to VDC and RANGE to 1000 volts.

c. Attach all covers and allow the 8100A to warm up for at least 1 hour.

4-63. Zero Adjustment

a. Set the 8100A to the 1000 volts dc range and short the input terminals.

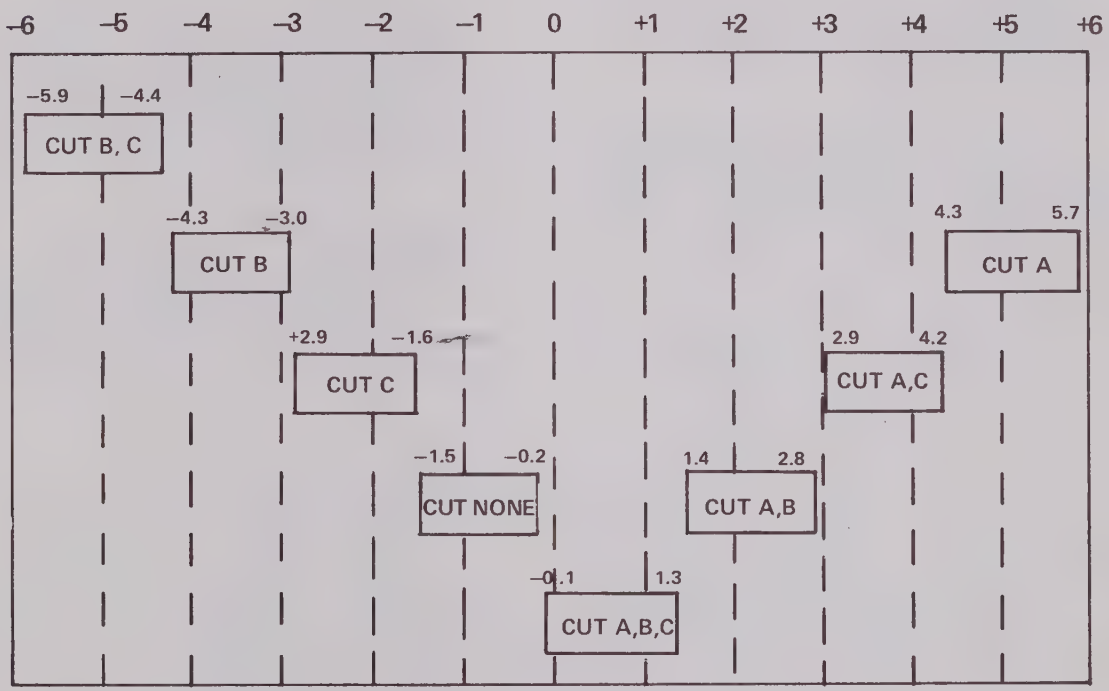
b. Remove the top and bottom outer covers.

c. Connect a dc differential voltmeter between TP1 and the LO INPUT terminal, with common lead

connected to INPUT LO and high lead connected to TP1.

d. Adjust the ZERO control (R175) for zero volt dc (±10 uV). If unable to obtain zero by adjusting R175, refer to the detailed procedure given in Figure 4-14.

MODEL 8100A READOUT



1. Connect Jumpers A, B and C. Jumpers may be identified as follows:

   Jumper A shunts R176
   Jumper B shunts R177
   Jumper C shunts R193

2. Set FUNCTION to VDC, RANGE to 1000, and FILTER to ON.

3. Turn ZERO adjust (R175) fully counterclockwise.

4. Note the readout and polarity indication and determine from the above chart which jumper wire (s) to cut.

5. Adjust R175 for a readout of 000.0.

Figure 4-14. ZERO ADJUSTMENT PROCEDURE

4-64. A-to-D Converter Offset

a. Disconnect the differential voltmeter from TP1.

b. Set the 8100A to the 1 volt dc range with the FILTER switch ON.

c. Apply +0.00055 volt dc to the input terminals.

d. Adjust the A-D OFFSET control (R206) for a readout alternating between .0005 and .0006. Check for proper adjustment by ensuring that the readout is (1) steady at +.0006 with a +0.00059 volt input and (2) steady at +.0005 with a +0.00053 volt input.

e. Reverse input polarity and ensure that readout is (1) steady at −.0006 with a −0.00059 volt input and (2) steady at −.0005 with a −0.00054 volt input.

4-65. −VDC Cal.

a. Set the 8100A to the 1 volt dc range with the FILTER switch ON.

b. Apply −1.00055 volts dc to the INPUT terminals.

c. Adjust −DCV CAL control (R23) for a readout alternating between −1.0005 and −1.0006. Check for proper adjustment by ensuring that the readout is (1) steady at −1.0006 with a −1.00058 volts input and (2) steady at −1.0005 with a −1.00052 volts input.

4-66. +VDC Cal.

a. Set the 8100A to the 1 volt dc range with the FILTER switch ON.

b. Apply +1.00055 volts dc to the INPUT terminals.

c. Adjust +DCV CAL control (R50) for a readout alternating between +1.0005 and +1.0006. Check for proper adjustment by ensuring that the readout is (1) steady at +1.0006 with a +1.00058 volts input and (2) steady at +1.0005 with a +1.00052 volts input.

4-67. Trip Point Adjustment

a. Set the 8100A to the 1 volt dc range with the FILTER switch ON.

b. Apply −0.09965 volt dc to the INPUT terminals.

c. Adjust the DCV TRIP POINT ADJ control (R208) for a readout alternating between −.099X and −.1000. Check for proper adjustment by ensuring that readout is (1) steady at −.099X with a −0.09993 volt input and (2) steady at −.1000 with a −0.09997 volt input.

NOTE!

The "X" digit may be any of several numbers, depending on adjustment of the REMAINDER ADJ control, which will be adjusted in the next section of the calibration procedure. The actual value does not affect trip point adjustment.

d. Reverse input polarity and ensure that readout is (1) steady at +.1000 with a +0.09999 volt input and (2) steady at +.099X with a +0.09992 volt input.

4-68. Remainder Adjustment

a. Set the 8100A to the 1 volt dc range.

b. Apply −0.09965 volt dc to the INPUT terminals.

c. Adjust the REMAINDER ADJ control (R149) for a readout alternating between −.0996 and −.0997. Check for proper adjustment by ensuring that readout is (1) steady at −.0997 with a −0.09966 volt input, (2) steady at −.0996 with a −0.09962 volt input, and (3) steady at +.0999 and −.0999 with +0.0999 and −0.0999 volt inputs respectively.

4-69. Input Divider Adjustment

a. Press the 100 volt RANGE switch.

b. Apply −100.00 volts dc to the INPUT terminals and adjust the INPUT DIV ADJ control (R157) for a readout of −100.00.

c. Apply −10.000 volts dc to the INPUT terminals and press the 10 volt RANGE switch. The instrument readout should be −10.000.

d. Press the 1000 volt RANGE switch and apply −1000.0 volts dc to the INPUT terminals. The instrument readout should be −1000.0.

e. Re-adjust the INPUT DIV ADJ control, if necessary, for an exact readout in steps (b), (c), and (d).

4-70. Kilohms Cal

a. Set the 8100A function to KΩ, RANGE to 1000, and FILTER to ON.

b. Connect a 100.00 kΩ resistor to the INPUT terminals.

c. Adjust K OHM CAL control (R48) for a 100.00 readout.

d. Set the 8100A to the 1 kΩ range.

e. Connect a 1.0000 kΩ resistor to the INPUT terminals. Readout should be 1.0000 ±0.0001 kΩ.

f. Set the 8100A to the 10 kΩ range.

g. Connect a 10.000 kΩ resistor to the INPUT terminals. Readout should be 10.000 ±0.001 kΩ.

h. Set the 8100A to the 1000 kΩ range.

i. Connect a 1000.0 kΩ resistor to the INPUT terminals. Readout should be 1000.0 ±0.1 kΩ.

j. Set the 8100A to the 1 kΩ range.

k. Short the INPUT terminals with a shorting bar. Readout should be < .0001.

4-71. 10 Megohm Cal

a. Set the 8100A function to 10 MΩ and FILTER to ON.

b. Connect a 10 MΩ resistor to the INPUT terminals.

c. Adjust the 10 MEG CAL control (R153) for a readout of 10.000 ±2 digits. Allow adequate time for instrument to settle before finalizing adjustment.

4-72. VAC Cal

a. Set 8100A function to VDC and RANGE to 1000. Ensure that readout is +000.0. If not, perform the zero adjustment procedure, paragraph 4 - 63.

b. Set 8100A function to VAC and RANGE to 1000. Readout should be between 000.0 and 000.3.

c. Set 8100A RANGE as shown in Table 4-7 and perform the indicated operations.

Table 4-7. AC CALIBRATION

STEP	8100A RANGE	INPUT SIGNAL	OPERATION
d.	1	1V, 1 kHz	Adjust ACV CAL (R134) for a readout of 1.0000.
e.	1	1V, 20 kHz	Adjust 1V HF ADJ (C14) for a readout of 1.0000.
f.	1	1V, 10 kHz	Readout should be between .9993 and 1.0008. If not, re-adjust C14 to bring reading within tolerance.
g.	1	1V, 10 kHz	Readout should be between .9975 and 1.0020.
h.	1	100 MV, 2 kHz	Readout should be between .0998 and .1002.
i.	1	100 MV, 10 kHz	Readout should be between .0996 and .1004.
j.	1	100 MV, 20 kHz	Readout should be between .0992 and .1008.
k.	10	10V, 2 kHz	Readout should be between 9.995 and 10.005
l.	10	10V, 20 kHz	Adjust 10V HF ADJ (C15) for a readout of 10.000.
m.	100	100V, 1 kHz	Readout should be between 99.93 and 100.07.
n.	100	100V, 20 kHz	Readout should be between 99.70 and 100.30.
o.	100	100V, 10 kHz	Readout should be between 99.70 and 100.30.
p.	1000	1000V, 2 kHz	Allow time for settling. Readout should be between 998.3 and 1001.7.
q.	1000	1000V, 10 kHz	Readout should be between 998.3 and 1001.7.
r.	1000	1000V, 20 kHz	Readout should be between 996.0 and 1004.0.
s.			Calibration of the 8100A is complete

Section 5
List of Replaceable Parts

5-1. INTRODUCTION

5-2. This section of the manual contains a listing of replaceable components for this instrument. The first listing contains a complete breakdown of all the major assemblies followed by subsequent listings that itemize the components on each major assembly. An illustration accompanies each major assembly listing to aid in locating the listed components.

5-3. Assemblies and subassemblies are identified by a reference designation beginning with the letter A followed by a number (e.g., A1 etc.). Electrical components appearing on the schematic diagram are identified by their schematic diagram reference designation. Components not appearing on the schematic diagram are consecutively numbered throughout the parts list. These components are identified with whole numbers on the arrow call-out illustrations and by index numbers on the grid illustrations. Flagnotes are used throughout the parts list and refer to special ordering explanations that are located in close proximity to the flagnotes.

5-4. COLUMN DESCRIPTION

a. The REF DESIG column indexes the item description to the associated illustration. In general the reference designations are listed under each assembly in alpha-numeric order. Subassemblies of minor proportions are sometimes listed with the assembly of which they are a part. In this case, the reference designations for the components of the subassembly may appear out of order.

b. The INDEX NO. column lists coordinates which locate the designated part on the associated grid illustrations.

c. The DESCRIPTION column describes the salient characteristics of the component. Indention of the description indicates the relationship to other assemblies, components, etc. In many cases it is necessary to abbreviate in this column. For abbreviations and symbols used, see Appendix B.

d. The six-digit part number, by which the item is identified at the John Fluke Mfg. Co., is listed in the STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives.

e. The Federal Supply Code for the item manufacturer is listed in the MFR column. An abbreviated list of Federal Supply Codes is included in the Appendix.

f. The part number which uniquely identifies the item to the original manufacturer is listed in the MFR PART NO. column. If a component must be ordered by description, the type number is listed.

g. The TOT QTY column lists the total quantity of the items used in the instrument and reflects the latest Use Code. Second and subsequent listings of the same item are referenced to the first listing with the abbreviation REF. In the case of optional subassemblies, plug ins, etc. that are not always part of the instrument, or are deviations from the basic instrument model, the TOT QTY column lists the total quantity of the item in that particular assembly.

h. Entries in the REC QTY column indicate the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of every part in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc. that are not always part of the instrument, or are deviations from the basic instrument model, the REC QTY column lists the recommended quantity of the item in that particular assembly.

i. The USE CODE column identifies certain parts which have been added, deleted or modified during

the production of the instrument. Each part for which a Use Code has been assigned may be identified with a particular instrument serial number by consulting the Serial Number Effectivity List at the end of the parts list. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part. In this event a parenthetical note is added in the DESCRIPTION column.

5-5. HOW TO OBTAIN PARTS

5-6. Standard components have been used wherever possible. Standard components may be ordered directly from the manufacturer by using the manufacturer's part number, or parts may be ordered from the John Fluke Mfg. Co. factory or authorized representative by using the Fluke part number. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-7. You can insure prompt and efficient handling of your order to the John Fluke Mfg. Co. if you include the following information:

a. Quantity
b. FLUKE Stock Number
c. Description
d. Reference Designation
e. Instrument model and serial number

Example: 2 each, 177105, Transistors, 2N3565, Q107-108 for 845AR, s/n 168.

If you must order structural parts not listed in the parts list, describe the part as completely as possible. A sketch of the part, showing its location to other parts of the instrument, is usually most helpful.

5-8. SERIAL NUMBER EFFECTIVITY

5-9. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 8100A. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all instruments with serial numbers above 123.

USE CODE	SERIAL NUMBER EFFECTIVITY
NONE	Model 8100A serial number 123 and on.
A	Model 8100A serial numbers 123, 132, 133, 136, 138, 140, 143-145, 148, 152-156, 160, 164, 166, 171 and on.
B	Model 8100A serial numbers 124-131, 134, 135, 137, 139, 141, 142, 146, 147, 149-151, 157-159, 161-163, 165, 167-170.
C	Model 8100A serial numbers 123 to approximately serial number 400.
D	Model 8100A approximately serial number 400 and on.
E	Model 8100A serial number 123 thru 1999.
F	Model 8100A serial number 2000 and on.
G	Model 8100A serial number 123 thru 2499.
H	Model 8100A serial number 2500 and on.
I	Model 8100A serial number 123 thru 2844.
J	Model 8100A serial number 2845 and on.
K	Model 8100A serial number 3410 thru 3419 and 4098 thru 4148.
L	Model 8100A serial number 4149 and on.
M	Model 8100A serial number 3410 thru 3419, 4098 thru 4365 and 4429 thru 4477.
N	Model 8100A serial number 4366 thru 4428 and 4478 and on.
O	Model 8100A serial number 123 thru 3409 and 3420 thru 4097.
P	Model 8100A serial number 3410 thru 3419 and 4098 and on.
Q	Model 8100A serial number 4260 and on.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DIGITAL MULTIMETER - Figure 5-1	8100A					
A1		Printed Circuit Assembly (See Figures 5-2 and 5-3)	269753	89536	269753	1		O
A1		Printed Circuit Assembly (See Figures 5-4 and 5-5)	294421	89536	294421	1		P
F1		Fuse, slow blow, 1/8 amp, 250v (for 115v operation)	166488	71400	MDL	1		
F1		Fuse, slow blow, 1/16 amp, 250v (for 230v operation)	163030	71400	MDL			
J1		Binding post, red, HI	275552	32767	820-65	1		
J2		Binding post, black, LO	275560	32767	820-45	1		
J3		Binding post, blue, GUARD	275578	32767	820-55	1		
P1		Connector, male, 3 contact	222612	82389	AC3G	1		
R1		Res, comp, 10m ±10%, ½w	108142	01121	EB1061	1		Q
S11		Switch, slide, dpdt	226274	82389	46256-LF	1		
T101		Transformer, power	275354	89536	275354	1	1	
W1		Line cord (not illustrated)	226100	70903	17258	1	1	
XF1		Holder, fuse	103283	71400	4405	1		
1		Cable, AC Power	269779	89536	169779	1		
2		Cable, Input	269761	89536	269761	1		
3		Cover, bottom (not illustrated)	269639	89536	269639	1		
4		Cover, top (not illustrated)	269647	89536	269647	1		
5		Handle, carrying	231456	89536	231456	1		
6		Push button, gray	268896	71590	J52304	9		
7		Push button, green	268862	71590	J61993	1		
8		Shaft, switch extension	269688	89536	269688	9		
9		Shorting link	101220	24655	0938-9712	1		

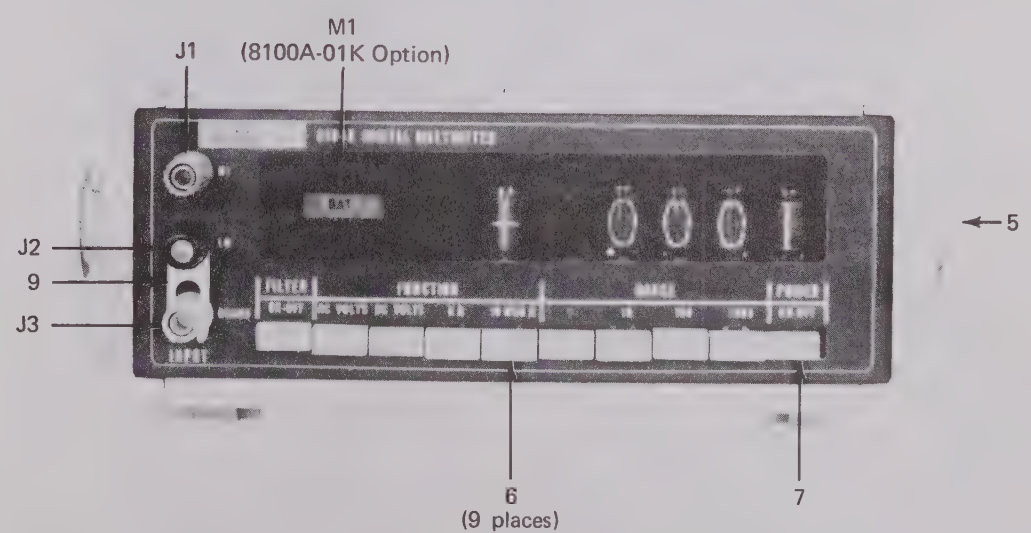


Figure 5-1. 8100A DIGITAL MULTIMETER (Sheet 1 of 2)

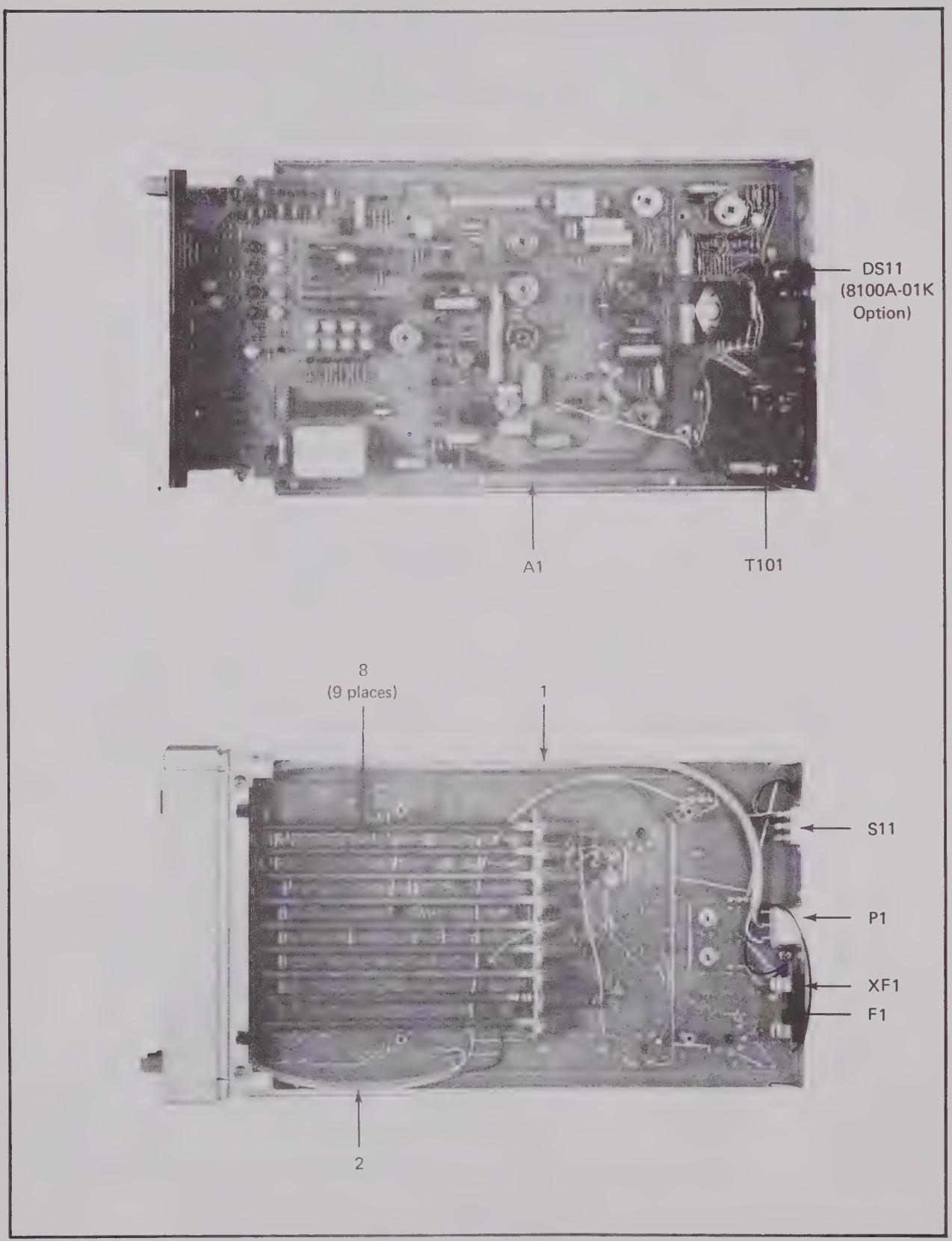


Figure 5-1. 8100A DIGITAL MULTIMETER (Sheet 2 of 2)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A1		**PRINTED CIRCUIT ASSEMBLY** **Figures 5-2 and 5-3**	269753	89536	269753	REF		O
		NOTE! *This assembly used in S/N 123 thru 3409 and 3420 thru 4097. For replacement, however, order the new configuration, part number 294421.*						
A1	G1-W2	IC, operational amplifier	268961	12040	SL6267	1	1	E
A1	G1-W2	IC, operational amplifier	271502	12040	LM301A	2	1	F
A2	E1-R5	IC, operational amplifier	271502	12040	LM301A	REF		
A3	C4-O5	IC, DTL, triple 3-input NAND gate	266312	04713	MC862P-6909	1		
A4	C4-N5	IC, DTL, Binary counter	267153	04713	MC839P-6921	1		
A5		IC, Decoder driver ,DM/SN7441AN, NS8840N	267211	89536	267211			
C1	B1-Z4	Cap, elect, 250 uf +50/−10%, 40v	178616	73445	C437ARG250	1	2	
C2	B3-R5	Cap, cer, 0.0012 uf ±10%, 500v	106732	71590	CF-122	2		E
C2	B3-R5	Cap, cer, 3300 pf ±20%, 1 kv	106674	56289	C023B102-G332M	1		F
C3	F1-X5	Cap, elect, 50 uf +75/−10%, 25v	148650	06001	76F02KL500	2		
C4	C1-R5	Cap, plstc, 0.47 uf, factory selected	279422	89536	279422	1		
C5	F4-Z4	Cap, elect, 50 uf +50/−10%, 25v	168823	73445	C426ARF50	3		
C6	B4-N1	Cap, elect, 2 uf +50/−10%, 150v	267310	56289	30D205F150-BB4	1	1	
C7	H1-X5	Cap, elect, 50 uf +75/−10%, 25v	148650	06001	76F02KL500	REF		
C8	I4-Y3	Cap, elect, 50 uf +50/−10%, 25v	168823	73445	C426ARF50	REF		
C9	I3-V1	Cap, plstc, 0.22 uf ±10%, 1 kv	275495	84411	Type 663UW	1		
C10	H2-V5	Cap, plstc, 0.1 uf ±20%, 120v	167460	84411	Type 863UW	1		
C11	H4-U5	Cap, plstc, 0.033 uf ±10%, 250v	234492	73445	C280AE/A33K	2		
C12	H5-V4	Cap, plstc, 0.068 uf ±20%, 120v	260570	84411	863UW68391	1		
C13	H4-U4	Cap, plstc, 0.027 uf ±10%, 250v	267120	73445	C280AE/A27K	1		
C14	D4-V5	Cap, var, 0.5−5 pf, 500v	267914	72982	532-001	1		
C15	D1-V5	Cap, var, 1−8 pf, 500v	267906	72982	532-000	1		
C18	D3-X2	Cap, elect, 50 uf +50/−10%, 25v	168823	73445	C426ARF50	REF		
C19	E2-W4	Cap, plstc, 1.0 uf ±10%, 250v	190330	73445	C280AE/A1M	3		
C20	E5-W4	Cap, plstc, 0.22 uf ±10%, 250v	194803	73445	C280AE/A220K	2		
C21	I3-O2	Cap, elect, 5 uf +50/−10%, 64v	218966	73445	C426ARH5	1		
C22	I1-N3	Cap, plstc, 0.1 uf, factory selected	279430	89536	279430	5		
C23	I1-N1	Cap, plstc, 0.1 uf, factory selected	279430	89536	79430	REF		
C24	I1-M4	Cap, plstc, 0.1 uf, factory selected	279430	89536	279430	REF		
C25	I1-M1	Cap, plstc, 0.1 uf, factory selected	279430	89536	279430	REF		
C26	I1-N5	Cap, plstc, 0.1 uf, factory selected	279430	89536	279430	REF		
C27	H4-O5	Cap, mica, 330 pf ±5%, 500v	148445	14655	CD15F331J	1		
C28	H4-O4	Cap, mica, 100 pf ±5%, 500v	148494	14655	CD15F101J	2		
C29	I1-P1	Cap, plstc, 0.47 uf ±10%, 250v	184366	73445	C280AE/A470K	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C30	H1-O2	Cap, plstc, 0.022 uf ±10%, 250v	234484	73445	C280AE/A22K	5		
C31	G5-O2	Cap, plstc, 0.022 uf ±10%, 250v	234484	73445	C280AE/A22K	REF		
C32	G4-O2	Cap, plstc, 0.022 uf ±10%, 250v	234484	73445	C280AE/A22K	REF		
C33	G2-O2	Cap, plstc, 0.022 uf ±10%, 250v	234484	73445	C280AE/A22K	REF		
C34	G5-O5	Cap, plstc, 0.047 uf ±20%, 120v	260562	84411	863UW47391	1		
C35	G5-P4	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A100K	4		
C36	E3-S1	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	3		
C37	F4-R4	Cap, plstc, 1.0 uf ±10%, 250v	190330	73445	C280AE/A1M	REF		
C38	C3-R4	Cap, cer, 0.0012 uf ±10%, 500v	106732	71590	CF-122	1		
C39	C3-S2	Cap, mica, 470 pf ±5%, 500v	148429	14655	CD19F471J	1		A
C39	C3-S2	Cap, mica, 220 pf ±5%, 500v	237008	14655	CD19F221J	1		B
C42	C4-P4	Cap, plstc, 0.047 uf ±10%, 250v	162008	73445	C280AE/A47K	1		
C43	D1-P4	Cap, plstc, 0.033 uf ±10%, 250v	234492	73445	C280AE/A33K	REF		
C44	B2-Q3	Cap, plstc, 1.0 uf ±10%, 250v	190330	73445	C280AE/A1M	REF		
C45	E1-S2	Cap, mica, 47 pf ±5%, 500v	148536	14655	CD15E470J	2		
C46	F4-R1	Cap, mica, 47 pf ±5%, 500v	148536	14655	CD15E470J	REF		
C48	H4-S1	Cap, elect, 1 uf +75/−10%, 25v	165886	56289	30D105G-025BA4	1		
C50	G2-X2	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A100K	REF		
C51	G2-W4	Cap, mica, 150 pf ±5%, 500v	148478	14655	CD15F151J	1		
C52	G1-X1	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	REF		
C53	D5-W3	Cap, mica, 100 pf ±5%, 500v	148494	14655	CD15F101J	REF		
C54	I4-Q4	Cap, plstc, 0.22 uf ±10%, 250v	194803	73445	C280AE/A220K	REF		
C55	G4-N1	Cap, mica, 4 pf ±5%, 500v (Figure 5-1)	190397	14655	CD15C040K	1		
C57	I1-M5	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	REF		
C58	H4-Y5	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A100K	REF		
C59	H4-Z2	Cap, plstc, 0.022 uf ±10%, 250v	234484	73445	C280AE/A22K	REF		
C60	D1-X5	Cap, cer, .001 uf ±20%, 3 kv	105635	56289	29C300	1		
C61	E4-U5	Cap, cer, 150 pf ±20%, 3 kv	277004	00656	HVD4150 ±20, 3 KV-2	1		
C62	H2-X2	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A100K	REF		
C63		Cap, factory selected (may or may not be installed)						E
C64	E1-M5	Cap, plstc, 2.2 uf ±10%, 250v	222232	73445	C280MAE/A2M2	1		F
CR1	B1-Y4	Diode, silicon, 1 amp, 100 piv	116111	05277	IN4817	7		
CR2	B1-Y3	Diode, silicon, 1 amp, 100 piv	116111	05277	IN4817	REF		
CR3	B3-M4	Diode, silicon, 1 amp, 600 piv	112383	05277	IN4822	2		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR4	D3-O2	Diode, silicon, 150 ma	203323	03508	DHD1105	11		
CR5	B3-R4	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR6	B3-R2	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR7	B4-P5	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR8	B4-P3	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR9	D3-O1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR10	I3-Y2	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR11	I1-W1	Diode, silicon, 10 ma, 2 piv	180554	07910	CD12599	2		
CR12	I1-W1	Diode, silicon, 10 ma, 2 piv	180554	07910	CD12599	REF		
CR13	I2-W1	Diode, silicon, 75 ma, 25 piv	241422	03508	1N4009	3		G
CR13	I2-W1	Diode, silicon, controlled FV	234468	07910	CD9039	2		H
CR14	F1-W3	Diode, silicon, 75 ma, 25 piv	241422	03508	1N4009	2		
CR15	F1-X1	Diode, silicon, 75 ma, 25 piv	241422	03508	1N4009	REF		
CR16	G4-R3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR17	H1-Q5	Diode, silicon, 200 ma, 25 piv	190272	93332	1N456A	4		
CR18	H1-S2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR19	B4-Q5	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR20	D1-P4	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR23	D1-S1	Diode, silicon 150 ma	203323	03508	DHD1105	REF		
CR26	E4-X1	Diode, silicon, 200 ma, 25 piv	190272	93332	1N456A	REF		
CR27	E4-W3	Diode, silicon, 200 ma, 25 piv	190272	93332	1N456A	REF		
CR29	D2-S1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR30	D2-R1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR35	G5-R3	Diode, silicon, 200 ma, 25 piv	190272	93332	1N456A	REF		
CR36	G1-P2	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR37	F1-X1	Diode, zener, 3.9v	113316	07910	1N748	1		
CR38	F1-N3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		F
CR39	B5-N1	Diode, silicon, 1 amp, 600 piv	112383	05277	1N4822	REF		F
CR40	I3-W1	(Figure 5-2) Diode, silicon, controlled FV	234468	07910	CD9039	REF		H
DS2	E3-K5	Lamp, Neon	266478	74276	A261	1	2	
F2	C2-Y2	Fuse, fast acting, ¼ amp, 250v	109314	71400	Type AGC	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q1	F2-Y4	Tstr, silicon, NPN	183004	95303	40250	1	1	
Q2	H1-Y3	Tstr, silicon, PNP	195974	04713	2N3906	9		
Q3	H3-Y3	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q4	B3-S2	Tstr, silicon, NPN	272237	07263	2N4946	2	2	
Q5	B2-S4	Tstr, silicon NPN	272237	07263	2N4946	REF		
Q6	G3-Z3	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q7	H1-Z3	Tstr, silicon, NPN	218396	04713	2N3904	11		
Q8	H3-Z3	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q9	H3-Y4	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q10	H3-Z1	Tstr, silicon, NPN	168716	07263	S19254	1		
Q11	H5-Z5	Tstr, factory selected & matched to R15 R22	1					
Q12	G2-R4	Tstr, factory selected & matched to Q52	2					
Q13	H3-Q3	Tstr, FET, N-channel	288324	15818	U1994E	18	4	
Q14	H3-R1	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q15	H3-R3	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q16	G3-R5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q17	G3-R2	Tstr, FET, N-channel	261578	15818	U1897E	1	2	
Q18	G2-Q5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q19	I3-N5	Tstr, silicon, PNP	281758	01295	SKA5153	5	4	
Q20	I3-N3	Tstr, silicon, PNP	281758	01295	SKA5153	REF		
Q21	I3-N1	Tstr, silicon, PNP	281758	01295	SKA5153	REF		
Q22	I3-M4	Tstr, silicon, PNP	281758	01295	SKA5153	REF		
Q23	I3-M1	Tstr, silicon, PNP	281758	01295	SKA5153	REF		
Q24	I1-L5	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q25	I3-P3	Tstr, silicon, PNP	281741	01295	SKA5198	1	1	
Q26	I3-P4	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q27	H1-P4	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q28	G3-P5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q29	H1-P5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q30	H1-N5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q31	G5-N5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q32	G4-N5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q33	G3-N5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q34	H1-O4	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q35	G3-O4	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q36	H1-P1	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q37	G3-P1	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q38	H1-P2	Tstr, FET, N-channel	288324	15818	U1994E	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q39	G3-P2	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q40	F1-P2	Tstr, germanium, NPN	182691	01295	GA3937	4	2	
Q41	E3-P2	Tstr, germanium, PNP	182709	01295	GA3938	4	2	
Q42	E1-P2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q43	F1-O5	Tstr, germanium, NPN	182691	01295	GA3937	REF		
Q44	E3-O5	Tstr, germanium, PNP	182709	01295	GA3938	REF		
Q45	E1-O5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q46	F1-O2	Tstr, germanium, NPN	182691	01295	GA3937	REF		
Q47	E3-O2	Tstr, germanium, PNP	182709	01295	GA3938	REF		
Q48	E1-O2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q49	F1-N5	Tstr, germanium, NPN	182691	01295	GA3937	REF		
Q50	E3-N5	Tstr, germanium, PNP	182709	01295	GA3938	REF		
Q51	E1-N5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q52	E3-R2	Tstr, Factory selected & matched to Q12	2					
Q53	G1-R5	Tstr, FET, dual, N-channel	257501	17856	DN423	1	1	
Q54	D3-R2	Tstr, silicon, NPN	222869	03508	X16E2300	1	1	
Q58	F1-R2	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q59	C4-S1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q60	C2-S1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q61	D3-S1	Tstr, silicon, PNP	281766	01295	SKA5152	2	1	
Q65	E2-M5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q66	E1-M2	Tstr, silicon, NPN	245480	07263	S24496	3	1	
Q67	H1-M5	Tstr, silicon, NPN	218511	95303	60994	4	2	
Q68	G3-M5	Tstr, silicon, NPN	218511	95303	60994	REF		
Q69	F5-M5	Tstr, silicon, NPN	218511	95303	60994	REF		
Q70	F2-M5	Tstr, silicon, NPN	218511	95303	60994	REF		
Q71	H1-M2	Tstr, silicon, PNP	266619	07263	2N4888	4	2	
Q72	G3-M2	Tstr, silicon, PNP	266619	07263	2N4888	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q73	F5-M2	Tstr, silicon, PNP	266619	07263	2N4888	REF		
Q74	F2-M2	Tstr, silicon, PNP	266619	07263	2N4888	REF		
Q75	G1-R2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q76	E1-R2	Tstr, silicon, PNP	281766	89536	281766	REF		
Q77	G4-W2	Tstr, FET, dual, N-channel	267963	17856	DN503	1	1	
Q79	F2-W2	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q80	F3-W4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q81	F4-L2	Tstr, silicon, NPN	245480	07263	S24496	REF		
Q82	G1-L1	Tstr, silicon, NPN	245480	07263	S24496	REF		
Q83	E4-R2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
R1	D5-Y3	Res, comp, 470Ω ±10%, 1w	109710	01121	GB4711	1		
R2	G4-Y3	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	5		
R3	G4-Y3	Res, comp, 33k ±5%, ¼w	148155	01121	CB3335	2		
R4	G4-Y2	Res, met flm, 38.3k ±1%, 1/8w	241372	91637	Type MFF1/8	1		
R5	H2-Y1	Res, met flm, 34k ±1%, 1/8w	261602	91637	Type MFF1/8	4		
R6	B4-R1	Res, met flm, 14.7k ±1%, 1/8w	226225	91637	Type MFF1/8	5		
R7	B5-S2	Res, met flm, 14.7k ±1%, 1/8w	226225	91637	Type MFF1/8	REF		
R8	B5-R1	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	5		
R9	G3-Z4	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R10	G4-Y4	Res, comp, 270Ω ±5%, ¼w	160804	01121	CB2715	2		
R11	G4-Z2	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R12	G4-Z1	Res, comp, 100k ±5%, ¼w	148189	01121	CB1045	1		
R13	H2-Z5	Res, met flm, 12.1k ±1%, 1/8w	234997	91637	Type MFF 1/8	1		
R14	H2-Z4	Res, met flm, 2.94k ±1%, 1/8w	261628	91637	Type MFF 1/8	1		
R15	G4-Y5	Res, met flm, factory matched to Q11 & R22	1					
R16	G4-Y4	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	7		
R17	G4-Z1	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	6		
R18	I3-AA2	Res, met flm, 10k ±1%, 1/8w	168260	91637	Type MFF 1/8	1		
R19	I3-AA1	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R20	I3-Z4	Res, met flm, 412Ω ±1%, 1/8w	261636	91637	Type MFF 1/8	1		
R21	I3-Z5	Res, met flm, 19.1k ±1%, 1/8w	234963	91637	Type MFF 1/8	3		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R22	I3-Z5	Res, met film, factory selected and matched to Q11 & R15	1					
R23	I1-Z2	Res, var, ww, 10k ±10%, 2w	272740	71450	Type 115	3		
R24	I2-S4	Res, met film, 1M ±0.1%, 2w	225953	03888	Type PME80	1		
R27	F4-V4	Res, comp, 1M ±10%, 2w	268227	01121	HB1051	1		
R28	G3-V4	Res, comp, 1.2M ±5%, ¼w	188425	01121	CB1255	1		
R29	G4-N2	Res, met film, 449.1k, matched (Figure 5–2)	3					
R30	G4-M5	Res, met film, 49.9k, matched (Figure 5–2)	3					
R31	G4-M5	Res, met film, 4.99k, matched (Figure 5–2)	3					
R32	G4-M4	Res, met film, 499Ω, matched (Figure 5–2)	3					
R34	C3-W5	Res, var, ww, 10k ±10%, 2w	272740	71450	Type 115	REF		
R35	E3-X1	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R36	E3-W2	Res, comp, 820k ±5%, ¼w	220541	01121	CB8245	1		
R37	G4-S2	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R39	G5-Q3	Res, comp, 18k ±5%, ¼w	148122	01121	CB1835	1		
R40	H5-S2	Res, met film, 14.7k ±1%, 1/8w	226225	91637	Type MFF 1/8	REF		
R42	H5-R2	Res, met film, 499k ±1%, 1/8w	268813	91637	Type MFF 1/8	1		
R43	H1-R3	Res, met film, 499k ±1%, 1/8w	268813	91637	Type MFF 1/8	REF		I
R43	H1-R3	Res, met film, 453k ±1%, 1/8w	295709	91637	Type MFF 1/8	1		J
R45	G5-Q5	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	8		
R46	H2-S2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R47	H3-S2	Res, met film, 14.7k ±1%, 1/8w	226225	91637	Type MFF 1/8	REF		
R48	G1-T4	Res, var, ww, 200Ω ±20%, 1-¼w	144766	71450	Type 110	1		
R49	G3-T2	Res, ww, 6.45k ±0.5%, ½w	184416	89536	184416	1		
R50	H2-T4	Res, var, ww, 15Ω ±20%, 1-¼w	163634	71450	Type 110	1		
R51	G5-T2	Res, ww, 2.85k ±0.1%, ½w	253450	89536	253450	1		
R52	G5-S2	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R53	H5-O3	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R54	I4-O3	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R56	I4-N5	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R57	I4-N3	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R58	I4-M5	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R59	I4-M3	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R60	I4-L5	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R61	I4-M1	Res, met flm, 200k ±1%, 1/8w	261701	91637	Type MFF 1/8	2		
R62	I1-O1	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R63	I1-N4	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R64	I1-N2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R65	I1-M5	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R66	H5-M3	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R67	H5-M3	Res, comp, 270k ±5%, ¼w	220061	01121	CB2745	1		
R68	I2-O5	Res, comp, 150k ±5%, ¼w	182212	01121	CB1545	2		
R69	I2-O4	Res, comp, 470k ±5%, ¼w	188441	01121	CB4745	2		
R70	H5-P4	Res, comp, 150k ±5%, ¼w	182212	01121	CB1545	REF		
R71	H5-Q1	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R72	H5-P3	Res, comp, 1.5M ±5%, ¼w	182857	01121	CB1555	2		
R73	H5-P3	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R74	H5-P5	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	14		
R75	F4-Q2	Res, met flm, 8.66k ±1%, 1/8w	260364	91637	Type MFF 1/8	1		
R77	G1-O1	Res, ww, 3.4483k, matched	4					
R78	F4-O5	Res, met flm, 422k ±1%, 1/8w	276626	91637	Type MFF 1/8	1		
R79	F5-P3	Res, ww, 200k, matched	4					
R80	D4-P3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R81	D4-P2	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	5		
R82	D4-P3	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	6		
R83	F2-P1	Res, met flm, 232k ±1%, 1/8w	276618	91637	Type MFF 1/8	1		
R84	F3-O4	Res, ww, 100k, matched	4					
R85	D4-O5	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R86	D4-O5	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R87	D4-P1	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	REF		
R88	F3-O1	Res, met flm, 121k ±1%, 1/8w	229369	91637	Type MFF 1/8	2		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R89	F4-O2	Res, ww, 50k, matched	4					
R90	D4-O3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R91	D4-O2	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R92	D4-O4	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R93	F2-O1	Res, met flm, 121k ±1%, 1/8w	229369	91637	Type MFF 1/8	REF		
R94	F3-O1	Res, ww, 50k, matched	4					
R95	D4-N5	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R96	D4-N4	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R97	D4-N5	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	REF		
R98	F2-P4	Res, ww, 200k, matched	4					
R99	G2-P4	Res, met flm, 11.8k ±1%, 1/8w	277145	91637	Type MFF 1/8	1		
R100	G2-P3	Res, met flm, 2k ±1%, 1/8w	277137	91637	Type MFF 1/8	1		
R101	H5-R2	Res, met flm, 19.1k ±1%, 1/8w	234963	91637	Type MFF 1/8	REF		
R102	E4-S1	Res, met flm, 34k ±1%, 1/8w	261602	91637	Type MFF 1/8	REF		
R103	E4-S1	Res, met flm,34k ±1%, 1/8w	261602	91637	Type MFF 1/8	REF		
R104	E3-R4	Res, met flm, 45.3k ±1%, 1/8w	234971	91637	Type MFF 1/8	1		
R108	D2-R2	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	2		
R110	D5-S1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R111	H2-S2	Res, met flm, 19.1k ±1%, 1/8w	234963	91637	Type MFF 1/8	REF		
R112	H4-R2	Res, comp, 2.2M ±5%, ¼w	198390	01121	CB2255	1		
R116	H5-Q1	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	9		
R118	D4-S1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R119	C4-R2	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R120	C2-R2	Res, comp, 33k ±5%, ¼w	148155	01121	CB3335	REF		
R121	C3-R2	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	5		
R122	D4-R2	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R123	D5-R2	Res, comp, 82k ±5%, ¼w	188458	01121	CB8235	1		
R124	D1-R2	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R127	F2-M3	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		C
R127	F2-M3	Res, comp, 12k ±5%, ¼w	159731	01121	CB1235	2		D
R128	E2-M4	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R130	E4-M3	Res, comp, 62k ±5%, ¼w	220053	01121	CB6235	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R131	H3-N2	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R132	G5-M3	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R133	G5-N2	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R134	G2-M3	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R135	G2-N2	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R136	F4-M3	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R137	F4-N2	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R138	F1-M3	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R139	E5-N1	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		E
R140	E5-N1	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	1		E
R141	G5-M3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R142	G2-M3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R143	F4-M3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R144	E5-M3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R145	E4-M3	Res, comp, 1.1k ±5%, ¼w	267336	01121	CB1125	1		
R146	C3-P4	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	REF		
R147	C5-P4	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	REF		
R149	E4-Q3	Res, var, ww, 500Ω ±10%, 1-¼w	112433	71450	Type 110	1		
R152	F2-T3	Res, met flm, 200k ±1%, 1/8w	261701	91637	Type MFF1/8	REF		
R153	E4-T4	Res, var, ww, 10k ±10%, 2w	272740	71450	Type 115	REF		
R154	F3-T3	Res, met flm, 34k ±1%, 1/8w	261602	91637	Type MFF 1/8	REF		
R155	B3-R4	Res, comp, 15Ω ±5%, ¼w	147876	01121	CB1505	1		
R156	E4-S5	Res, met flm, 8.987M ±0.1%, 2w	261453	03888	Type PME80	1	1	
R157	C5-T1	Res, var, comp, 50k ±30%, ¼w	281667	71450	Type U201	1		
R158	C2-T2	Res, ww, 900k, matched	5				1 SET	
R159	B5-U3	Res, ww, 90k, matched	5					
R160	D3-T5	Res, ww, 10k, matched	5					
R161	D3-W4	Res, met flm, 14.7k ±1%, 1/8w	226225	91637	Type MFF 1/8	REF		
R162	D3-W5	Res, met flm, 1.18k ±1%, 1/8w	268409	91637	Type MFF 1/8	1		
R163	G4-X1	Res, met flm, 35k ±0.1%, 1/8w	229443	91637	Type MFF 1/8	2		
R164	G3-X1	Res, met flm, 35k ±0.1%, 1/8w	229443	91637	Type MFF 1/8	REF		
R165	H2-X1	Res, met flm, 46.4k ±1%, 1/8w	188375	91637	Type MFF 1/8	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R166	F4-X1	Res, comp, 12k ±5%, ¼w	159731	01121	CB1235	REF		
R169	F4-W2	Res, comp, 270Ω ±5%, ¼w	160804	01121	CB2715	REF		
R170	F1-W2	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R172	F5-X1	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R174	E1-W4	Res, met flm, 453Ω ±1%, 1/8w	267393	91637	Type MFF 1/8	1		
R175	I2-W5	Res, var, ww, 10Ω ±10%, 2w	183921	71450	Type 115	1	1	
R176	I2-X3	Res, met flm, 28.7Ω ±1%, 1/8w	272823	91637	Type MFF 1/8	1		
R177	H2-W5	Res, met flm, 13.7Ω ±1%, 1/8w	272815	91637	Type MFF 1/8	1		
R179	F4-X1	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R180	F2-S1	Res, comp, 470k ±5%, ¼w	188441	01121	CB4745	REF		
R181	I1-Y3	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R184	E5-R2	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R185	E5-S1	Res, comp, 1.5M ±5%, ¼w	182857	01121	CB1555	REF		
R186	G2-Q3	Res, comp, factory selected	▷6					
R187	G1-Q5	Res, comp, 3.3Ω ±5%, ¼w	182279	01121	CB33G5	1		
R188	G5-Q4	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R189	H1-R3	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R191	G2-O4	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R193	H2-W5	Res, comp, 6.2Ω ±5%, ¼w	272831	01121	CB62G5	1		
R194	F5-W3	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	REF		
R195	I1-Y4	Res, comp, 470Ω ±5%, ¼w	147983	01121	CB4715	2		
R196		Res, comp, 470Ω ±5%, ¼w	147983	01121	CB4715	REF		
R197	I3-Q2	Res, comp, 27Ω ±5%, ¼w	160812	01121	CB2705	1		
R198	H2-X3	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
S1 thru S10	A4-M4	Switch assembly, front, S1 – S10	279406	89536	279406	1	1	
	F4-M4	Switch assembly, rear, S1 – S10 (Figure 5-2)	279448	89536	279448	1	1	
T102	B3-O3	Transformer, inverter	253583	89536	253583	1	1	
V1	D5-K4	Tube, neon readout	266502	83594	B-5750S	4	4	
V2	D2-K4	Tube, neon readout	266502	83594	B-5750S	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
V3	C3-K4	Tube, neon readout	266502	83594	B-5750S	REF		
V4	B5-K4	Tube, neon readout	266502	83594	B-5750S	REF		
V5	F1-K4	Tube, polarity indicator	272922	83594	B-5856ST	1	1	
XA3, XA4	C5-O1	Socket, IC, 14 contact	276527	23880	TSA-2900-14W	2		
XA5	D1-N2	Socket, IC, 16 contact	276535	23880	TSA-2900-16W	1		
XDS2	E3-L2	Socket, lamp	279372	89536	279372	1		
XF1		Fuse holder clip	284984	84613	3621-2	2		
XV1 thru XV5	D3-L2	Socket, tube	268714	83594	SK207	5		
		Cover, tube (not illustrated)	281550	89536	281550	1		
	F5-Y5	Heat sink, Q1	186759	89536	186759	1		

1 Q11, R15 and R22 are a matched set and must be replaced as a set. For replacement, order Reference Amplifier Set, part number 269803.

2 Q12 and Q52 are a J-FET matched set and must be replaced as a set. For replacement, order part number 265744.

3 R29 thru R32 are a matched set and must be replaced as a set. For replacement, order AC Converter Resistor Set, part number 257014.

4 R77, R79, R84, R89, R94 and R98 are a matched Ladder Divider Resistor Set, part number 269795. However, the resistors may be replaced individually if model, serial number, full reference designation and all information stamped on the old resistor are included when ordering a new one.

5 R158, R159 and R160 are a matched set and must be replaced as a set. For replacement, order Input Divider Resistor Set, part number 269787.

6 R186 is factory selected. For replacement, replace with exact value.

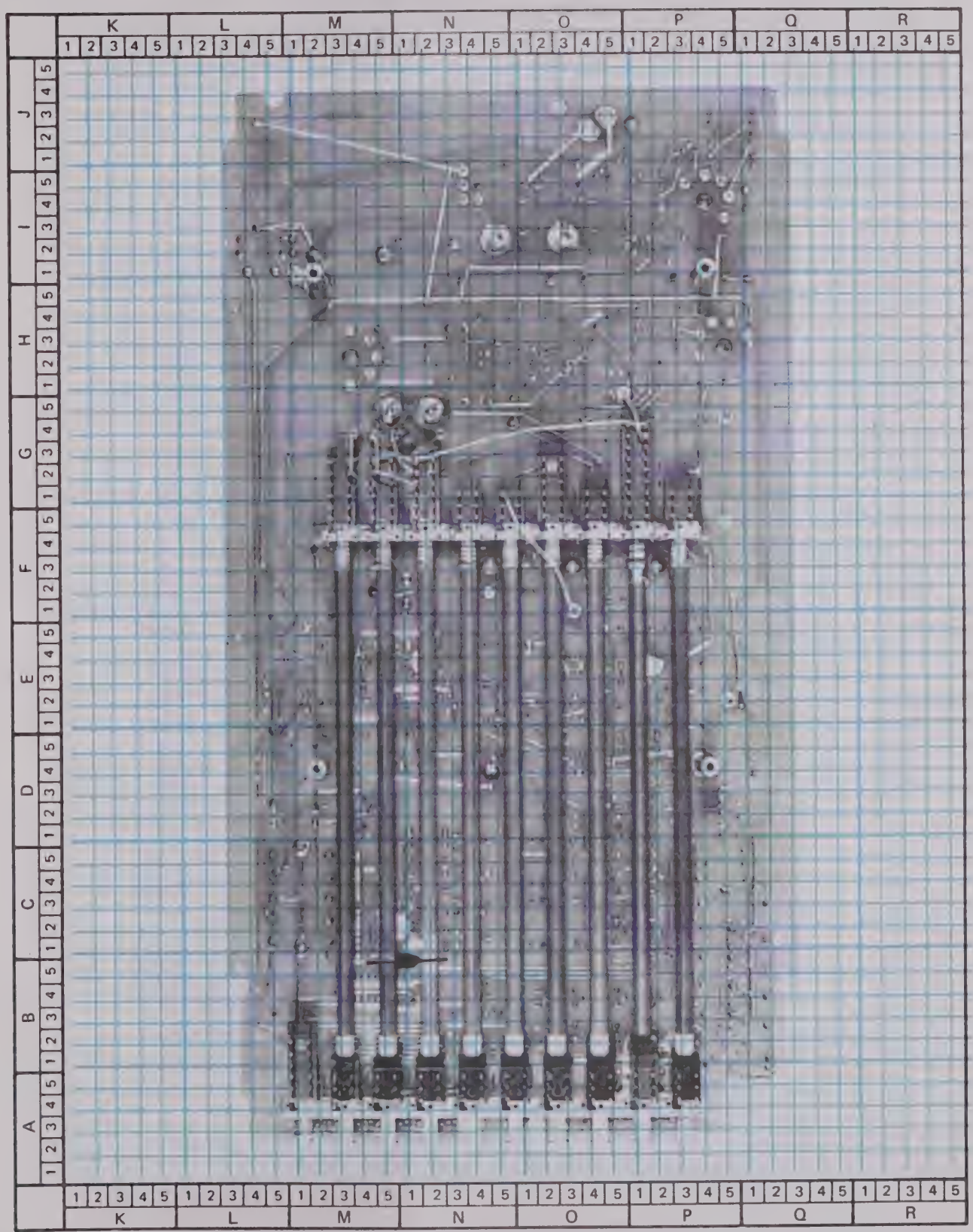


Figure 5-2. PRINTED CIRCUIT ASSEMBLY (S/N 123 THRU 3409 AND 3420 THRU 4097)

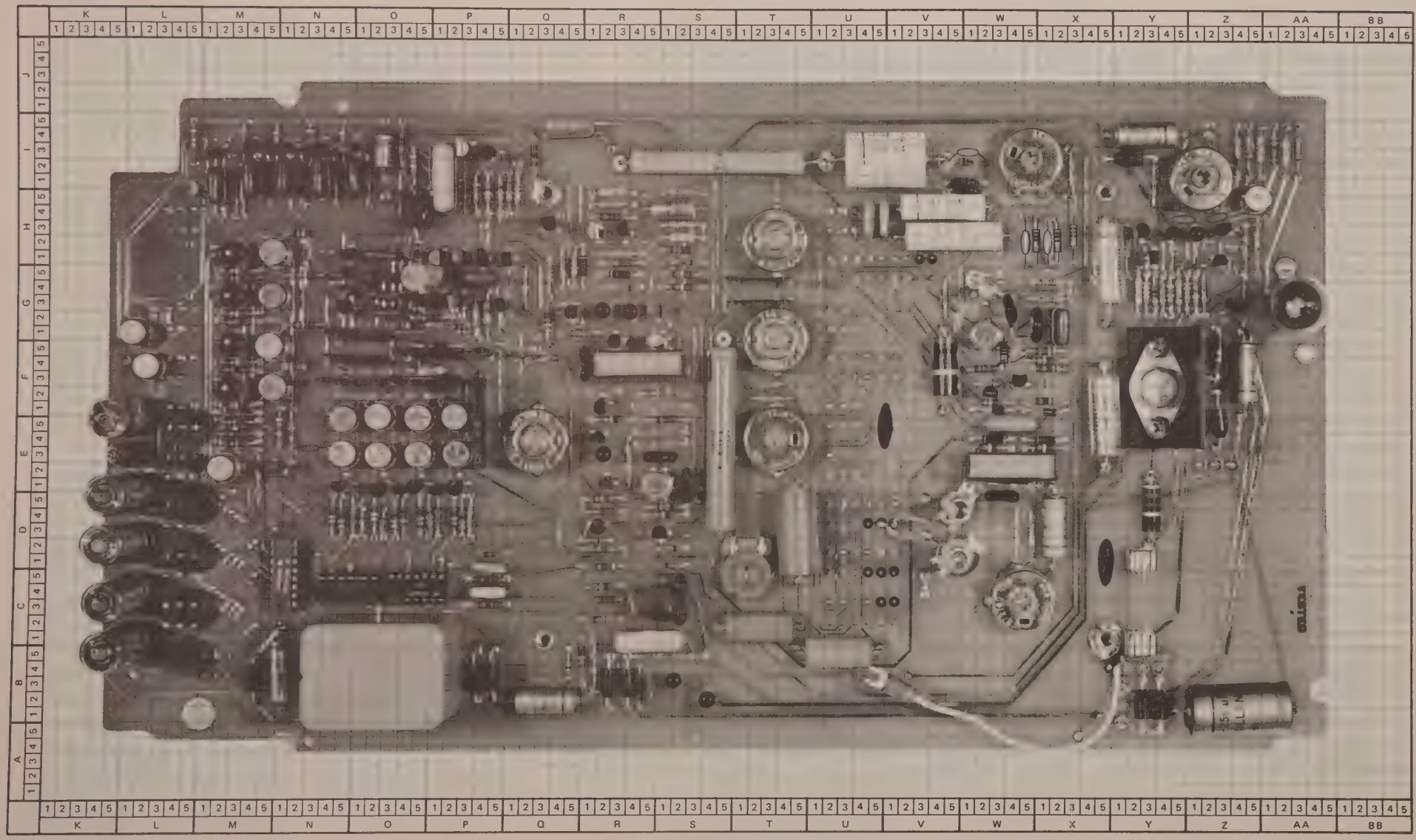


Figure 5-3. PRINTED CIRCUIT ASSEMBLY (S/N 123 THRU 3409 AND 3420 THRU 4097)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A1		**PRINTED CIRCUIT ASSEMBLY** **Figures 5-4 and 5-5** *NOTE!* *This assembly used in S/N 3410 thru 3419 and 4098 and on. Use this assembly for replacement in all serial numbers.*	294421	89536	294421	REF		P
A1	G1-W1	IC, operational amplifier	271502	12040	LM301A	2	1	
A2	E3-S1	IC, operational amplifier	271502	12040	LM301A	REF		
A3	D1-P2	IC, DTL, triple 3-input NAND gate	266312	04713	MC862P-6909	1		
A4	D1-O3	IC, DTL, Binary counter	267153	04713	MC839P-6921	1		
A5	D2-N4	IC, Decoder driver, DM/SN7441AN, NS8840N	267211	89536	267211	1	1	
C1	B4-Z1	Cap, elect, 250 uf +50/−10%, 40v	178616	73445	C437ARG250	1	1	
C2	B5-S1	Cap, cer, 3300 pf ±20%, 1 kv	106674	56289	C023B102-G332M	1		
C3	F1-X3	Cap, elect, 50 uf + 75/−10%, 25v	148650	06001	76F02KL500	2		
C4	C3-S1	Cap, plstc, 0.47 uf, factory selected	279422	89536	279422	1		
C5	F4-Z1	Cap, elect, 50 uf +50/−10%, 25v	168823	73445	C426ARF50	3		
C6	C1-N4	Cap, elect, 2 uf +50/−10%, 150v	267310	56289	30D205F150-BB4	1	1	
C7	G4-X3	Cap, elect, 50 uf +75/−10%, 25v	148650	06001	76F02KL500	REF		
C8	I3-X5	Cap, elect, 50 uf +50/−10%, 25v	168823	73445	C426ARF50	REF		
C9	I2-U5	Cap, plstc, 0.22 uf ±10%, 1 kv	275495	84411	Type 663UW	1		
C10	H2-V3	Cap, plstc, 0.1 uf ±20%, 120v	167460	84411	Type 863UW	1		
C11	H3-U4	Cap, plstc, 0.033 uf ±10%, 250v	234492	73445	C280AE/A33K	2		
C12	H4-V3	Cap, plstc, 0.068 uf ±20%, 120v	260570	84411	863UW68391	1		
C13	H3-U4	Cap, plstc, 0.027 uf ±10%, 250v	267120	73445	C280AE/A27K	1		
C14	E1-V4	Cap, var, 0.5−5 pf, 500v	267914	72982	532-001	1		
C15	D3-V4	Cap, var, 1−8 pf, 500v	267906	72982	532-000	1		
C18	D4-W5	Cap, elect, 50 uf +50/−10%, 25v	168823	73445	C426ARF50	REF		
C19	E3-W2	Cap, plstc, 1.0 uf ±10%, 250v	190330	73445	C280AE/A1M	3		
C20	E5-W2	Cap, plstc, 0.22 uf ±10%, 250v	194803	73445	C280AE/A220K	2		
C21	I2-O5	Cap, elect, 5 uf +50/−10%, 64v	218966	73445	C426ARH5	1		
C22	H5-O1	Cap, plstc, 0.1 uf, factory selected	279430	89536	279430	5		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C23	H5-N4	Cap, plstc, 0.1 uf, factory selected	279430	89536	279430	REF		
C24	H5-N2	Cap, plstc, 0.1 uf, factory selected	279430	89536	279430	REF		
C25	H5-M5	Cap, plstc, 0.1 uf, factory selected	279430	89536	279430	REF		
C26	H5-O3	Cap, plstc, 0.1 uf, factory selected	279430	89536	279430	REF		
C27	H4-P2	Cap, mica, 330 pf ±5%, 500v	148445	14655	CD15F331J	1		
C28	H4-P2	Cap, mica, 100 pf ±5%, 500v	148494	14655	CD15F101J	1		
C29	I1-P4	Cap, plstc, 0.47 uf ±10%, 250v	184366	73445	C280AE/A470K	1		
C30	H1-O5	Cap, plstc, 0.022 uf ±10%, 250v	234484	73445	C280AE/A22K	6		
C31	G5-O5	Cap, plstc, 0.022 uf ±10%, 250v	234484	73445	C280AE/A22K	REF		
C32	G4-O5	Cap, plstc, 0.022 uf ±10%, 250v	234484	73445	C280AE/A22K	REF		
C33	G2-O5	Cap, plstc, 0.022 uf ±10%, 250v	23448	73445	C280AE/A22K	REF		
C34	G5-P2	Cap, plstc, 0.047 uf ±10%, 120v	260562	84411	863UW47391	1		
C35	G4-P5	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A100K	5		
C36	E5-S1	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	3		
C37	F4-R5	Cap, plstc, 1.0 uf ±10%, 250v	190330	73445	C280AE/A1M	REF		
C38	C5-R5	Cap, cer, 0.0012 uf ±10%, 500v	106732	71590	CF-122	1		
C39	G5-S3	Cap, mica, 470 pf ±5%, 500v	148429	14655	CD19F471J	1		
C42	D1-Q2	Cap, plstc, 0.047 uf ±10%, 250v	162008	73445	C280AE/A47K	1		
C43	D3-Q1	Cap, plstc, 0.033 uf ±10%, 250v	234492	73445	C280AE/A33K	REF		
C44	B4-Q5	Cap, plstc, 1.0 uf ±10%, 250v	190330	73445	C280AE/A1M	REF		
C45	E3-S3	Cap, mica, 47 pf ±5%, 500v	148536	14655	CD15E470J	2		
C46	F4-R1	Cap, mica, 47 pf ±5%, 500v	148536	14655	CD15E470J	REF		
C48	H3-S2	Cap, elect, 1 uf +75/−10%, 25v	165886	56289	30D105G-025BA4	1		
C50	G1-W4	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A100K	REF		
C51	G1-W3	Cap, mica, 150 pf ±5%, 500v	148478	14655	CD15F151J	1		
C52	G2-W1	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	REF		
C54	I3-R1	Cap, plstc, 0.22 uf ±10%, 250v	194803	73445	C280AE/A220K	REF		
C55	G4-N2	Cap, mica, 4 pf ±5%, 500 v (Figure 5-4)	190397	14655	CD15C040K	1		
C57	H4-N3	Cap, mica, 33 pf ±5%, 500v	160317	14655	CD15E330J	REF		
C58	H2-Y2	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A100K	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C59	H3-Y4	Cap, plstc, 0.022 uf ±10%, 250v	234484	73445	C280AE/A22K	REF		
C60	D3-X3	Cap, cer, 0.001 uf ±20%, 3 kv	105635	56289	29C300	1		
C61	F1-U5	Cap, cer, 150 pf ±20%, 3 kv	277004	00656	HVD4150 ±20, 3 KV-2	1		
C62	H2-W5	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A22K	REF		
C64	G3-Y2	Cap, plstc, 0.022 uf ±10%, 250v	234484	73445	C280AE/A22K	REF		
C65	D1-N1	Cap, elect, 4 uf +50/−10%, 400v	241398	56289	34D405F400-EJ2	1		M
C65	D1-N1	Cap, elect, 3 uf +50/−10%, 250v	306555	56289	500D305F250-DC7	1		N
C66	G1-W3	Cap, plstc, 0.1 uf ±10%, 250v	161992	73445	C280AE/A100K	REF		
CR1	B4-Y1	Diode, silicon, 1 amp, 100 piv	116111	05277	IN4817	7		
CR2	B4-X5	Diode, silicon, 1 amp, 100 piv	116111	05277	IN4817	REF		
CR3	C1-N2	Diode, silicon, 1 amp, 600 piv	112383	05277	1N4822	2		
CR4	D5-O4	Diode, silicon, high speed switching	289595	03508	1N4148	12		
CR5	B5-R4	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR6	B5-R3	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR7	C1-Q1	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR8	C1-P5	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR10	I1-X4	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR11	H5-V4	Diode, silicon, 10 ma, 2 piv	180554	07910	CD12599	2		
CR12	H5-V4	Diode, silicon, 10 ma, 2 piv	180554	07910	CD12599	REF		
CR13	I1-V4	Diode, silicon, 150 ma	234468	07910	CD9039	2		
CR14	F1-W1	Diode, silicon, 75 ma, 25 piv	241422	03508	1N4009	2		
CR15	F1-W4	Diode, silicon, 75 ma, 25 piv	241422	03508	1N4009	REF		
CR16	G4-R4	Diode, silicon, high speed switching	289595	03508	1N4148	REF		
CR17	G5-R1	Diode, silicon, 200 ma, 25 piv	190272	93332	1N456A	2		
CR18	G5-S3	Diode, silicon, high speed switching	289595	03508	1N4148	REF		
CR19	C1-R1	Diode, silicon, high speed switching	289595	03508	1N4148	REF		
CR20	D4-Q2	Diode, silicon, high speed switching	289595	03508	1N4148	REF		
CR23	D2-R5	Diode, silicon, high speed switching	289595	03508	1N4148	REF		
CR26	E4-W4	Diode, silicon, high speed switching	289595	03508	1N4148	REF		

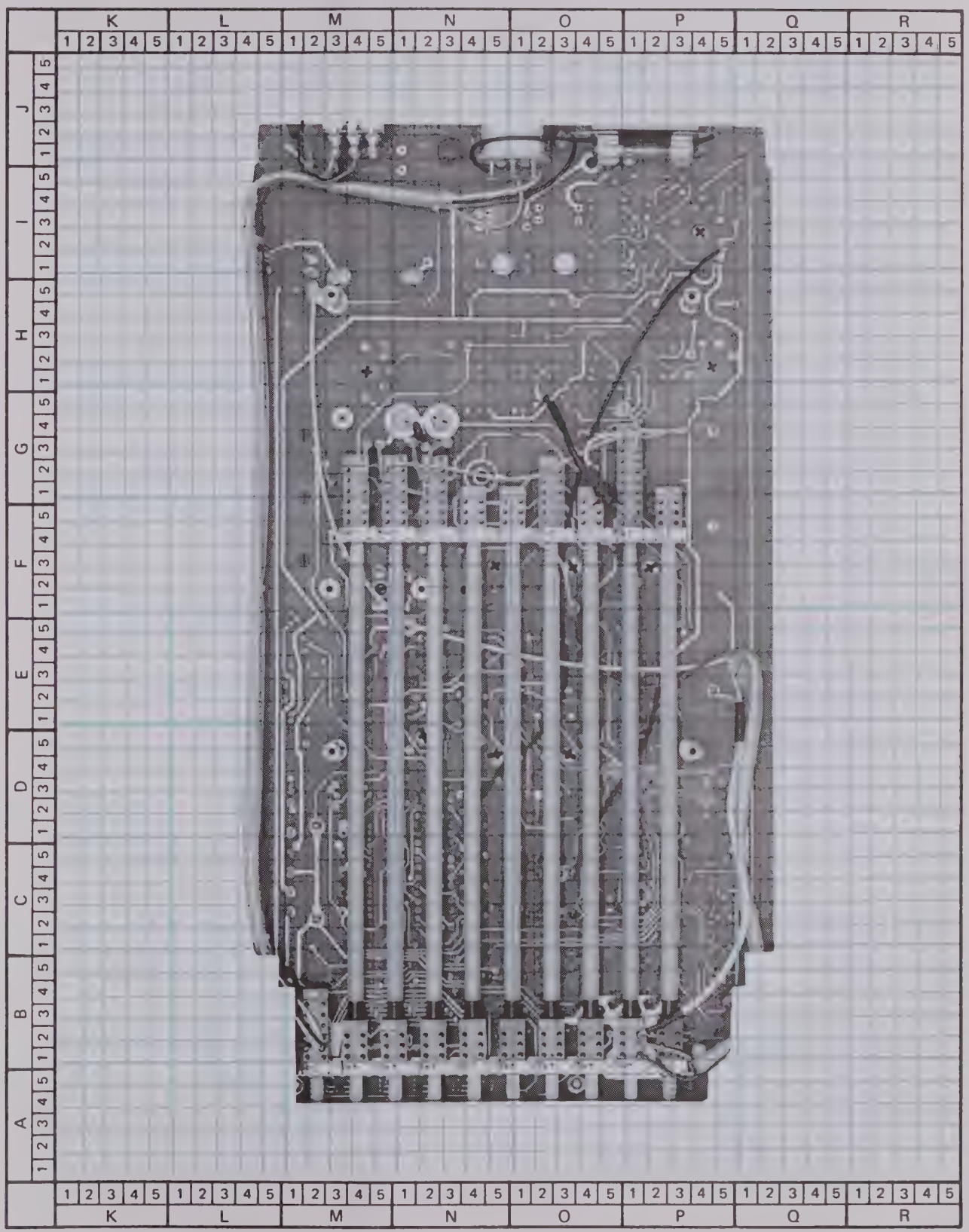


Figure 5-4. PRINTED CIRCUIT ASSEMBLY (S/N 3410 THRU 3419 AND 4098 AND ON)

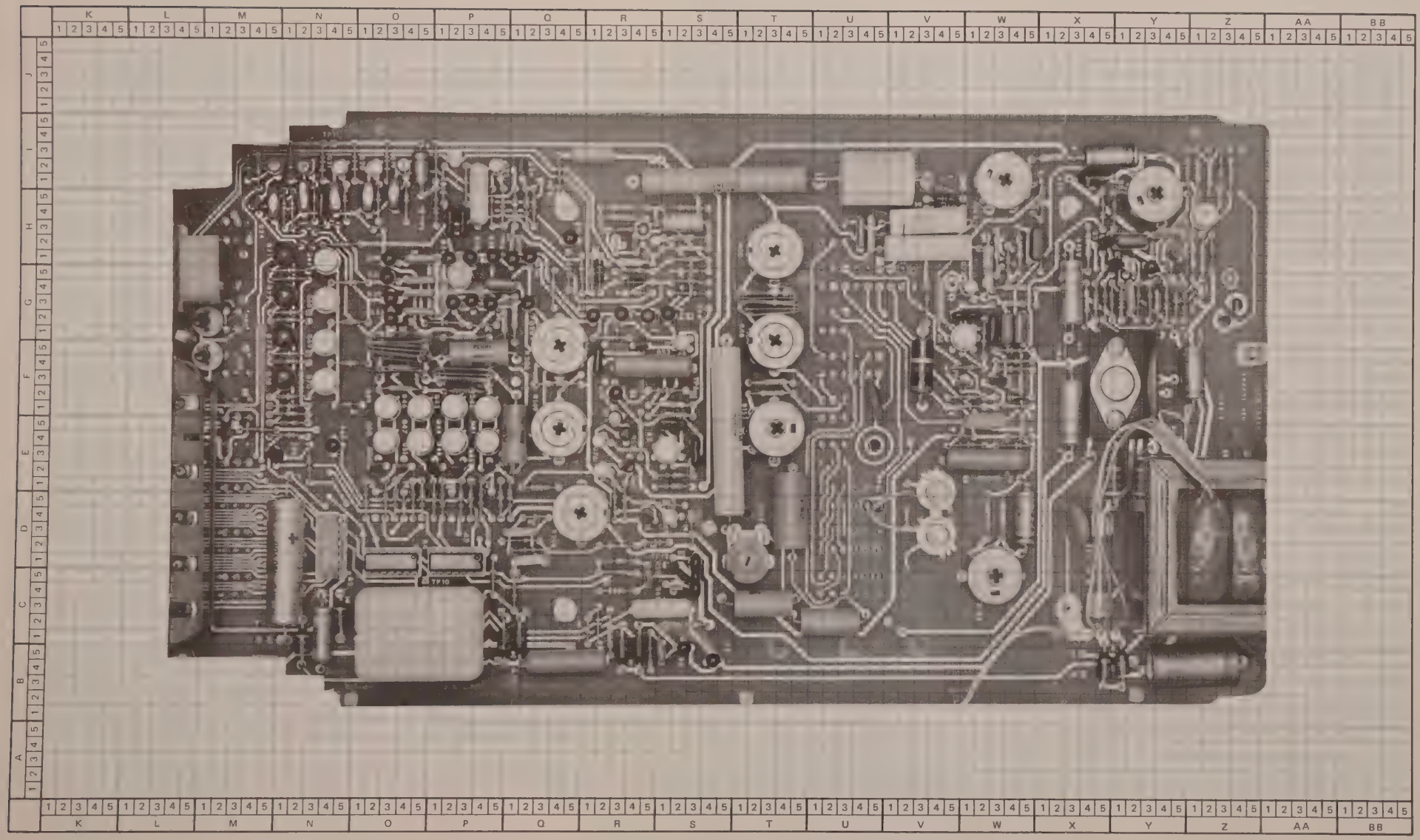


Figure 5-5. PRINTED CIRCUIT ASSEMBLY (S/N 3410 THRU 3419 AND 4098 AND ON)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR27	E4-V5	Diode, silicon, high speed switching	289595	03508	1N4148	REF		
CR35	G4-R4	Diode, silicon, 200 ma, 25 piv	190272	93332	1N456A	REF		
CR36	G2-P4	Diode, silicon, high speed switching	289595	03508	1N4148	REF		
CR37	F2-W4	Diode, zener, 3.9v	113316	07910	1N748	1		
CR45	C3-N5	Diode, silicon, 1 amp, 600 piv	112383	05277	1N4822	REF		
CR46	F1-N5	Diode, silicon, high speed switching	289595	03508	1N4148	REF		
CR47	D3-S3	Diode, silicon, high speed switching	289595	03508	1N4148	REF		
CR48	D5-S1	Diode, silicon, high speed switching	289595	03508	1N4148	REF		
CR49	I1-V4	Diode, silicon, 150 ma	234468	07910	CD9039	REF		
DS2	E4-L5	Lamp, Neon	266478	74276	A261	1	2	
F2	D1-X5	Fuse, fast acting, ¼amp, 250v	109314	71400	Type AGC	1		
Q1	F3-Y1	Tstr, silicon, NPN	183004	95303	40250	1	1	
Q2	H1-Y1	Tstr, silicon, PNP	195974	04713	2N3906	9		
Q3	H2-X5	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q4	B5-S2	Tstr, silicon, NPN	272237	07263	2N4946	2	2	
Q5	B5-S4	Tstr, silicon, NPN	272237	07263	2N4946	REF		
Q6	G4-Z1	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q7	H1-Y5	Tstr, silicon, NPN	218396	04713	2N3904	11		
Q8	H1-Y5	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q9	H1-Y2	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q10	H1-Y3	Tstr, silicon, NPN	168716	07263	S19254	1		
Q11	H4-Z2	Tstr, factory selected & matched to R15 and R22	1					
Q12	G2-R5	Tstr, factory selected & matched to Q52	2					
Q13	H2-Q5	Tstr, FET, N-channel	288324	15818	U1994E	19	4	
Q14	H2-R3	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q15	H2-R4	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q16	G2-S1	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q17	G2-R3	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q18	G2-R1	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q19	I2-O3	Tstr, silicon, PNP	288761	49956	RS2048	9	4	

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q20	I2-O2	Tstr, silicon, PNP	288761	49956	RS2048	REF		
Q21	I2-N4	Tstr, silicon, PNP	288761	49956	RS2048	REF		
Q22	I2-N2	Tstr, silicon, PNP	288761	49956	RS2048	REF		
Q23	I2-M5	Tstr, silicon, PNP	288761	49956	RS2048	REF		
Q24	H5-M4	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q25	I2-P5	Tstr, silicon, PNP	288761	49956	RS2048	REF		
Q26	I2-Q1	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q27	H1-Q1	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q28	G3-Q2	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q29	H1-Q2	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q30	H1-O3	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q31	G5-O3	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q32	G3-O3	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q33	G2-O3	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q34	H1-P1	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q35	G3-P2	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q36	H1-P3	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q37	G3-P3	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q38	H1-P4	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q39	G3-P4	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q40	F1-P4	Tstr, germanium, NPN	182691	01295	GA3937	4	2	
Q41	E4-P4	Tstr, germanium, PNP	182709	01295	GA3938	4	2	
Q42	E2-P4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q43	F1-P2	Tstr, germanium, NPN	182691	01295	GA3937	REF		
Q44	E4-P2	Tstr, germanium, PNP	182709	01295	GA3938	REF		
Q45	E2-P2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q46	F1-O5	Tstr, germanium, NPN	182691	01295	GA3937	REF		
Q47	E4-O5	Tstr, germanium, PNP	182709	01295	GA3938	REF		
Q48	E2-P1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q49	F1-O3	Tstr, germanium, NPN	182691	01295	GA3937	REF		
Q50	E4-O3	Tstr, germanium, PNP	182691	01295	GA3938	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q51	E2-O4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q52	E4-R3	Tstr, Factory selected & matched to Q12	2					
Q53	F5-S2	Tstr, FET, dual, N-channel	257501	17856	DN423	1	1	
Q58	F2-R3	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q59	D1-S1	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q60	C4-S2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q65	E4-N4	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q66	E3-M5	Tstr, silicon, NPN	245480	07263	S24496	3	1	
Q67	H1-N3	Tstr, silicon, NPN	218511	95303	60994	4	2	
Q68	G3-N3	Tstr, silicon, NPN	218511	95303	60994	REF		
Q69	F5-N3	Tstr, silicon, NPN	218511	95303	60994	REF		
Q70	F3-N3	Tstr, silicon, NPN	218511	95303	60994	REF		
Q71	H1-N1	Tstr, silicon, PNP	266619	07263	2N4888	4	2	
Q72	G3-N1	Tstr, silicon, PNP	266619	07263	2N4888	REF		
Q73	G1-N1	Tstr, silicon, PNP	266619	07263	2N4888	REF		
Q74	F3-N1	Tstr, silicon, PNP	266619	07263	2N4888	REF		
Q75	F5-R4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q76	E4-R2	Tstr, silicon, PNP	288761	49956	RS2048	REF		
Q77	G4-W1	Tstr, FET, dual, N-channel	267963	17856	DN503	1	1	
Q79	F3-W1	Tstr, silicon, PNP	195974	04713	2N3906	REF		
Q80	F3-W3	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q81	F4-L5	Tstr, silicon, NPN	245480	07263	S24496	REF		
Q82	G2-L5	Tstr, silicon, NPN	245480	07263	S24496	REF		
Q84	E2-O2	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q85	E5-R3	Tstr, FET, N-channel	261578	15818	U2366E	1		
Q86	D4-R5	Tstr, silicon, NPN	168708	03508	2N3391	2		
Q87	E2-R4	Tstr, silicon, NPN	168708	03508	2N3391	REF		
Q88	E2-R2	Tstr, silicon, PNP	288761	49956	RS2048	REF		
Q89	D4-S1	Tstr, silicon, PNP	288761	49956	RS2048	REF		
R1	E1-Y1	Res, comp, 470Ω ±10%, 1w	109710	01121	GB4711	1		
R2	G3-X5	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	6		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R3	G3-X4	Res, comp, 33k ±5%, ¼w	148155	01121	CB3335	3		
R4	G3-X4	Res, met flm, 38.3k ±1%, 1/8w	241372	91637	Type MFF1/8	1		
R5	H2-X4	Res, met flm, 34k ±1%, 1/8w	261602	91637	Type MFF1/8	4		
R6	C1-R2	Res, met flm, 14.7k ±1%, 1/8w	226225	91637	Type MFF1/8	5		
R7	C2-S2	Res, met flm, 14.7k ±1%, 1/8w	226225	91637	Type MFF1/8	REF		
R8	C2-R2	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	5		
R9	H1-Z2	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R10	G3-X5	Res, comp, 270Ω ±5%, ¼w	160804	01121	CB2715	2		
R11	G3-Y5	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R12	G3-Y5	Res, comp, 100k,±5%, ¼w	148189	01121	CB1045	1		
R13	H1-Z1	Res, met flm, 12.1k ±1%, 1/8w	234997	91637	Type MFF 1/8	1		
R14	H1-Z1	Res, met flm, 2.94k ±1%, 1/8w	261628	91637	Type MFF 1/8	1		
R15	G3-Y3	Res, met flm, factory matched to Q11 and R22	1					
R16	G3-Y1	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	8		
R17	G3-Y4	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	6		
R18	I2-Z3	Res, met flm, 10k ±1%, 1/8w	168260	91637	Type MFF 1/8	1		
R19	I2-Z3	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R20	I2-Y5	Res, met flm, 412Ω ±1%, 1/8w	261636	91637	Type MFF 1/8	1		
R21	I2-Z2	Res, met flm, 19.1k ±1%, 1/8w	148023	01121	CB1025	6		
R22	I2-Z1	Res, met flm, factory selected and matched to Q11 and R15	1					
R23	I1-Y3	Res, var, ww, 10k ±10%, 2w	272740	71450	Type 115	3		
R24	I1-S4	Res, met flm, 1M ±0.1%, 2w	225953	03888	Type PME80	1		
R27	F4-V3	Res, comp, 1M ±10%, 2w	268227	01121	HB1051	1		
R28	G3-V3	Res, comp, 1.2M ±5%, ¼w	188425	01121	CB1255	1		
R29	G3-N3	Res, met flm, 449.1k, matched (Figure 5-4)	3					
R30	G3-N2	Res, met flm, 49.9k, matched (Figure 5-4)	3					
R31	G3-M5	Res, met flm, 4.99k, matched (Figure 5-4)	3					
R32	G3-M4	Res, met flm, 499Ω, matched (Figure 5-4)	3					

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R34	D1-W3	Res, var, ww, 10k ±10%, 2w	272740	71450	Type 115	REF		
R35	E4-W4	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R36	E4-W1	Res, comp, 820k ±5%, ¼w	220541	01121	CB8245	1		
R37	G4-S2	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R39	G5-Q4	Res, comp, 18k ±5%, ¼w	148122	01121	CB1835	1		
R40	H4-S2	Res, met flm, 14.7k ±1%, 1/8w	226225	91637	Type MFF1/8	REF		
R42	H4-R3	Res, met flm, 499k ±1%, 1/8w	268813	91637	Type MFF1/8	1		
R43	H1-R3	Res, met flm, 453k ±1%, 1/8w	295709	91637	Type MFF1/8	1		
R45	G5-R1	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	8		
R46	H1-S2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R47	H2-S2	Res, met flm, 14.7k ±1%, 1/8w	226225	91637	Type MFF1/8	REF		
R48	G1-T4	Res, var, ww, 200Ω ±20%, 1–¼w	144766	71450	Type 110	2		
R49	G3-T3	Res, ww, 6.45k ±0.5%, ½w	184416	89536	184416	1		
R50	H1-T4	Res, var, ww, 10Ω ±10%, 1-¼w	112672	71450	Type 110	1		
R51	G4-T3	Res, ww, 2.853k ±0.03%, ½w	291039	89536	291039	1		
R52	G4-S2	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R53	H4-P1	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R54	I2-P1	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R56	I2-O2	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R57	I2-N5	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R58	I2-N3	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R59	I2-N1	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R60	I2-M3	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R61	I2-M4	Res, met flm, 200k ±1%, 1/8w	261701	91637	Type MFF1/8	2		
R62	H5-O4	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R63	H5-O2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R64	H5-N5	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R65	H5-N3	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R66	H4-N1	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R67	H4-N1	Res, comp, 270k ±5%, ¼w	220061	01121	CB2745	1		
R68	I1-P3	Res, comp, 150k ±5%, ¼w	182212	01121	CB1545	2		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R69	I1-P1	Res, comp, 470k ±5%, ¼w	188441	01121	CB4745	2		
R70	H4-Q1	Res, comp, 150k ±5%, ¼w	182212	01121	CB1545	REF		
R71	H4-Q2	Res, comp, 22k ±5%, ¼w	148130	01121	CB2235	REF		
R72	H4-P4	Res, comp, 1.5M ±5%, ¼w	182857	01121	CB1555	1		
R73	H4-P5	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R74	H4-Q2	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	13		
R75	F3-Q4	Res, met flm, 8.66k ±1%, 1/8w	260364	91637	Type MFF1/8	1		
R77	G1-O3	Res, ww, 3.4483k, matched	4					
R78	G1-P3	Res, met flm, 422k ±1%, 1/8w	276626	91637	Type MFF1/8	1		
R79	F5-P4	Res, ww, 200k, matched	4					
R80	D5-Q1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R81	D5-P5	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	5		
R82	D5-P4	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	6		
R83	F2-P3	Res, met flm, 232k ±1%, 1/8w	276618	91637	Type MFF1/8	1		
R84	F3-P3	Res, ww, 100k, matched	4					
R85	D5-P2	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R86	D5-P3	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R87	D5-P1	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	REF		
R88	F4-O3	Res, met flm, 121k ±1%, 1/8w	229369	91637	Type MFF1/8	2		
R89	F5-O4	Res, ww, 50k, matched	4					
R90	D5-O5	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R91	D5-P1	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R92	D5-O4	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R93	F2-O3	Res, met flm, 121k ±1%, 1/8w	229369	91637	Type MFF1/8	REF		
R94	F3-O2	Res, ww, 50k, matched	4					
R95	D5-O3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R96	D5-O3	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R97	D5-O1	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	REF		
R98	E5-Q1	Res, ww, 200k, matched	4					
R99	G2-P5	Res, met flm, 11.9k ±0.25%, 1/8w	290007	91637	Type MFF1/8	1		
R100	G2-Q1	Res, met flm, 2k ±0.25%, 1/8w	289991	91637	Type MFF1/8	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R101	H4-R3	Res, met flm, 19.1k ±1%, 1/8w	234963	91637	Type MFF1/8	REF		
R102	F1-S1	Res, met flm, 34k ±1%, 1/8w	261602	91637	Type MFF1/8	REF		
R103	F1-S1	Res, met flm, 34k ±1%, 1/8w	261602	91637	Type MFF1/8	REF		
R104	E4-R4	Res, met flm, 45.3k ±1%, 1/8w	234971	91637	Type MFF1/8	1		
R110	E2-S1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R111	H2-S2	Res, met flm, 19.1k ±1%, 1/8w	234963	91637	Type MFF1/8	REF		
R112	H3-R3	Res, comp, 2.2M ±5%, ¼w	198390	01121	CB2255	2		
R118	E1-S1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R119	D1-R3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R120	C4-R3	Res, comp, 33k ±5%, ¼w	148155	01121	CB3335	REF		
R121	C5-R3	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	7		
R124	D2-R3	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	1		
R127	F1-N1	Res, comp, 12k ±5%, ¼w	159731	01121	CB1235	2		
R128	E2-N3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R130	E4-N1	Res, comp, 62k ±5%, ¼w	220053	01121	CB6235	1		
R131	H2-N5	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	8		
R132	G5-N1	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R133	G4-N5	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R134	G2-N1	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R135	G2-N5	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R136	F5-N1	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R137	F4-N5	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R138	F2-N1	Res, comp, 180k ±5%, ¼w	193441	01121	CB1845	REF		
R141	G5-N1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R142	G2-N1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R143	F4-N1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R144	F1-N1	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R145	E5-N1	Res, comp, 1.1k ±5%, ¼w	267336	01121	CB1125	1		
R146	C4-Q1	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	REF		
R147	D2-Q2	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	REF		
R149	E4-O4	Res, var, ww, 200Ω ±20%, 1-¼w	144766	71450	Type 110	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R152	F2-T3	Res, met flm, 200k ±1%, 1/8w	261701	91637	Type MFF1/8	REF		
R153	E5-T3	Res, var, ww, 10k ±10%, 2w	272740	71450	Type 115	REF		
R154	F3-T3	Res, met flm, 34k ±1%, 1/8w	261602	91637	Type MFF1/8	REF		
R155	B5-R5	Res, comp, 15Ω ±5%, ¼w	147876	01121	CB1505	1		
R156	E3-S5	Res, met flm, 8.987M ±0.1%, 2w	261453	03888	Type PME80	1	1	
R157	D1-T1	Res, var, comp, 50k ±30%, ¼w	281667	71450	Type U201	1		
R158	C3-T3	Res, ww, 900k, matched	5				1 SET	
R159	C2-U2	Res, ww, 90k, matched	5					
R160	D4-T4	Res, ww, 10k, matched	5					
R161	D4-W2	Res, met flm, 14.7k ±1%, 1/8w	226225	91637	Type MFF1/8	REF		
R162	D4-W3	Res, met flm, 1.18k ±1%, 1/8w	268409	91637	Type MFF1/8	1		
R163	G4-W4	Res, met flm, 35k ±0.1%, 1/8w	229443	91637	Type MFF1/8	2		
R164	G3-W4	Res, met flm, 35k ±0.1%, 1/8w	229443	91637	Type MFF1/8	REF		
R165	H2-W4	Res, met flm, 46.4k ±1%, 1/8w	188375	91637	Type MFF1/8	1		
R166	F4-W4	Res, comp, 12k ±5%, ¼w	159731	01121	CB1235	REF		
R169	F4-W1	Res, comp, 270Ω ±5%, ¼w	160804	01121	CB2715	REF		
R170	F2-W1	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	REF		
R172	F5-W4	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R174	E1-W2	Res, met flm, 453Ω ±1%, 1/8w	267393	91637	Type MFF1/8	1		
R175	I1-W4	Res, var, ww, 200Ω ±10%, 2w	184465	71450	Type 115	1	1	
R176	H5-X1	Res, met flm, 13.7Ω ±1%, 1/8w	272815	91637	Type MFF1/8	1		
R177	H2-W3	Res, met flm, 28.7Ω ±1%, 1/8w	272823	91637	Type MFF1/8	1		
R178	F4-W4	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R180	F2-S1	Res, comp, 47k ±5%, ¼w	148163	01121	CB4735	REF		
R181	H4-X5	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	REF		
R186		Res, comp, factory selected	6					
R187	G1-R2	Res, comp, 3.3Ω±5%, ¼w	182279	01121	CB33G5	1		
R188	G5-Q5	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R189	G5-R4	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R191	G2-P1	Res, comp, 220k ±5%, ¼w	160937	01121	CB2245	REF		
R193	H1-W3	Res, comp, 6.2Ω ±5%, ¼w	272831	01121	CB62G5	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R194	G1-W2	Res, comp, 1.6k ±5%, ¼w	266197	01121	CB1625	REF		
R195	H4-Y1	Res, comp, 470Ω ±5%, ¼w	147983	01121	CB4715	2		
R196	H3-Y2	Res, comp, 470Ω ±5%, ¼w	147983	01121	CB4715	REF		
R197	I2-Q4	Res, comp, 27Ω ±5%, ¼w	160812	01121	CB2705	1		
R198	H1-X1	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R199	G3-Y2	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R200	G3-Y3	Res, comp, 2.2M ±5%, ¼w	198390	01121	CB2255	REF		
R201	D2-Q1	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R202	C5-P5	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R203	H1-W2	Res, met flm, 2M ±1%, ½w	217760	91637	Type MFF ½	1		
R204	I3-X1	Res, met flm, 715k ±1%, 1/8w	236836	91637	Type MFF1/8	1		
R205	G4-Q3	Res, comp, 470k ±5%, ¼w	188441	01121	CB4745	REF		
R206	G1-Q4	Res, var, ww, 5Ω ±20%, 1-¼w	166348	71450	Type 110	1		
R207	E1-Q3	Res, comp, 33k ±5%, ¼w	148155	01121	CB3335	REF		
R208	D5-Q5	Res, var, ww, 500Ω ±10%, 1-¼w	112433	71450	Type 110	1		
R209	D5-R3	Res, comp, 82k ±5%, ¼w	188458	01121	CB8235	1		
R210	D5-R3	Res, comp, 1M ±5%, ¼w	182204	01121	CB1055	1		
R211	E5-M4	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
S1 thru S10	B1-N2	Switch assembly, front, S1 – S10	279406	89536	279406	1	1	
	F4-N2	Switch assembly, rear, S1 – S10 (Figure 5-4)	279448	89536	279448	1	1	
T102	C1-O5	Transformer, inverter	253583	89536	253583	1	1	
V1	E2-L4	Tube, neon readout	266502	83594	B-5750S	4	4	K
V1	E2-L4	Tube, neon readout	271494	83594	B5853ST	4		L
V2	D4-L4	Tube, neon readout	266502	83594	B-5750S	REF		K
V2	D4-L4	Tube, neon readout	271494	83594	B5853ST	REF		L
V3	D1-L4	Tube, neon readout	266502	83594	B-5750S	REF		K
V3	D1-L4	Tube, neon readout	271494	83594	B5853ST	REF		L
V4	C3-L4	Tube, neon readout	266502	83594	B-5750S	REF		K
V4	C3-L4	Tube, neon readout	271494	83594	B5853ST	REF		L
V5	F1-L4	Tube, polarity indicator	272922	83594	B-5856ST	1	1	
XA3, XA4	C5-O3	Socket, IC, 14 contact	276527	23880	TSA-2900-14W	2		
XA5	D2-N5	Socket, IC, 16 contact	276535	23880	TSA-2900-16W	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
XDS2	F1-L5	Socket, lamp	279372	89536	279372	1		
XF1	C3-X5	Fuse holder clip	284984	84613	3621-2	2		
XV1 thru XV5		Socket, tube	268714	83594	SK207	5		
	D2-L5	Cover, tube	281550	89536	281550	1		
	F4-Y3	Heat sink, Q1	186759	89536	186759	1		

1 Q11, R15 and R22 are a matched set and must be replaced as a set. For replacement, order Reference Amplifier Set, part number 269803.

2 Q12 and Q52 are a J-FET matched set and must be replaced as a set. For replacement, order part number 265744.

3 R29 thru R32 are a matched set and must be replaced as a set. For replacement, order AC Converter Resistor Set, part number 257014.

4 R77, R79, R84, R89, R94 and R98 are a matched Ladder Divider Resistor Set, part number 269795. However, the resistors may be replaced individually if model , serial number, full reference designation and all information stamped on the old resistor are included when ordering a new one.

5 R158, R159 and R160 are a matched set and must be replaced as a set. For replacement, order Input Divider Resistor Set, part number 269787.

6 R186 is factory selected. For replacement, replace with exact value.

SECTION VI

ACCESSORIES AND OPTIONS

6-1. INTRODUCTION

6-2. This section of the manual contains information pertaining to the accessories and options which are available for the Model 8100A Digital Multimeter. Accessory information consists of a brief description of the accessory and its specifications. Option information is designated by the option number, which is printed in the top corner of each page. Option information includes the field installation procedure, operating instructions, and list of replaceable parts.

6-3. ACCESSORIES

6-4. High Frequency Probe

6-5. The High Frequency Probe (Fluke Model 80-RF) converts the Model 8100A into a high frequency ac voltmeter. The probe is used for ac voltage measurements of 0.25 volts to 30 volts over a frequency range of 100 kHz to 500 MHz. The accuracy of measurement is ±5% from 100 kHz to 100 MHz and ±7% to 500 MHz over a temperature range of +10°C to +30°C. The probe operates into any dc voltmeter with an input resistance of 10 megohms ±10%. The shielded dual-banana plug on the probe permits direct connection to voltmeter input. Additional specifications for the probe are listed in Figure 6-1.

6-6. High Voltage Probes

6-7. The 80F-5 and 80F-15 Voltage Dividers (Figure 6-2) are designed for use with the Model 8100A Digital Multimeter. Full-scale input for the Model 80F-5 is 5000 volts dc and for the Model 80F-15 is 15,000 volts dc. In use, the dividers simply plug in to the Model 8100A input terminals, and high voltage connection is made using the attached probe. Figure 6-3 gives the specifications for both dividers.

VOLTAGE RANGE: 0.25V to 30V.

RESPONSE: Responds to peak value of input. Calibrated to read rms value of a sine wave input.

AC to DC TRANSFER ACCURACY:

Loaded with 10 megohm ±10%.

	100 kHz	100 MHz	500 MHz
+10°C to +30°C	±5%	±7%	
−10°C to +40°C	±7%	±15%	

<±3 db at 10 kHz and 700 MHz.

INPUT IMPEDANCE: 4 megohms shunted by 2 ±0.5 pf.

MAXIMUM INPUT: 30 volts rms AC, 200 volts DC.

CABLE CONNECTION: Shielded dual banana plug Fits all standard 3/4-inch dual banana connectors.

CABLE LENGTH: 4 ft (121.9 cm) minimum.

WEIGHT: 3-½ oz net.

ACCESSORIES SUPPLIED: Ground Lead
Straight Tip
Hook Tip
High Frequency Adapter

Figure 6-1. HIGH FREQUENCY PROBE CHARACTERISTICS

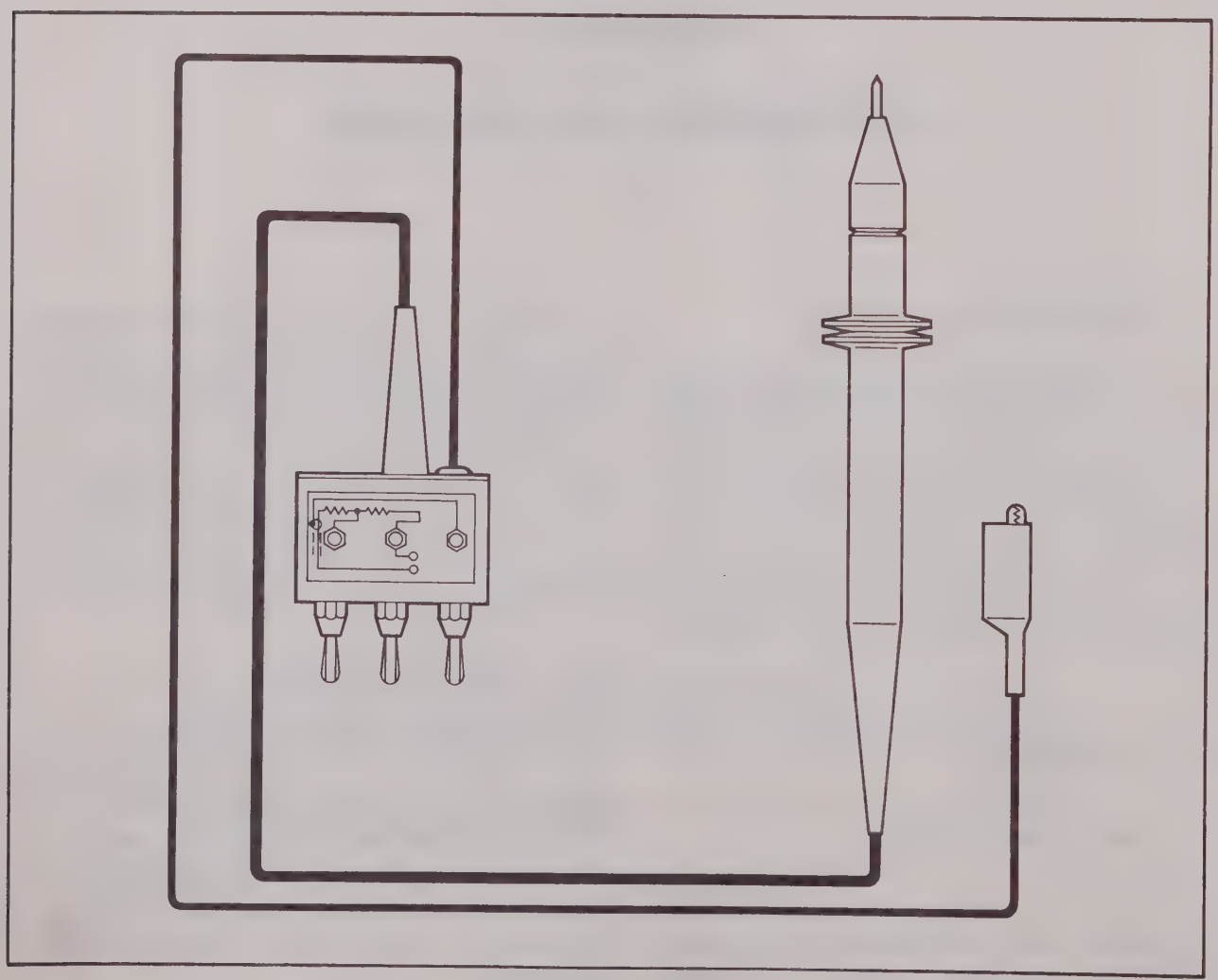


Figure 6-2. MODEL 80F-5/80F-15 HIGH VOLTAGE PROBES

PARAMETER	SPECIFICATIONS	
	MODEL 80F-5	MODEL 80F-15
Ratio Accuracy	±0.01% of input from 500 to 5000 vdc.	±0.01% of input from 1000 to 15,000 vdc.
Stability of Ratio	±0.01% per month, ±0.05% per year (recalibrated by internal adjustment)	
Temperature Coefficient	0.001%/°C	
Voltage Coefficient	< 20 ppm total from 0 to 5000 vdc	< 20 ppm total from 0 to 15,000 vdc
Division Ratio	1000 : 1	
Maximum Input Voltage	5000 vdc	15,000 vdc
Input Impedance	50 MΩ	100 MΩ
Operating Temperature Range	0°C to 50°C.	
Humidity Range	0 to 80%	
Altitude Range	Operating: 0 to 10,000 ft. Non-operating: 0 to 50,000 ft.	
Weight	12 oz.	24 oz.

Figure 6-3. VOLTAGE DIVIDER SPECIFICATIONS

6-8. Switched AC/DC Current Shunts

6-9. The Model A90 Current Shunt (Figure 6-4) enables the Model 8100A to be used for ac and dc current measurements to 10 amperes. The Model A90 is supplied in half-rack case to match the Model 8100A. The instruments may be conveniently mounted together in a 19-inch rack, with the Model A90 output terminals adjacent to the Model 8100A input terminals. The Model A90 provides six full-scale ranges as follows: 0.1, 1, 10, 100, and 1000 milliamps and 10 amperes (ac or dc). Full-scale input on any Model A90 range provides 100 millivolts dc to the input of the Model 8100A.

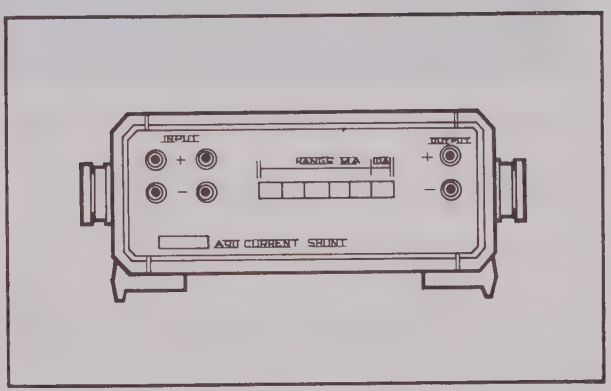


Figure 6-4. MODEL A90 CURRENT SHUNT

6-10. Front Panel Dust Cover

6-11. The vacuum-formed dust cover (Figure 6-5) attaches to the front of the Model 8100A. It prevents accumulation of dust on the front panel when the instrument is not in use and it affords added protection for the instrument when it is in transit. The Fluke number for the dust cover is 252205.

6-12. Rack Mount Kits

6-13. There are two rack mount kits available for the Model 8100A. One kit (No. 243287) allows two Model 8100A multimeters to be mounted side-by-side in a standard 19 inch rack, as shown in Figure 6-6. The two instruments are connected together at the center of the rack by two number 10 machine screws (not supplied). Holes for these screws are located in the front casting and are accessible after removing the decal at the side of the casting. The rack ears fasten to the front casting at either side, and are each held in place by two existing screws located under the decal. The second kit (No. 256594) supplies the hardware necessary to mount one Model 8100A in the center of the rack. In this case the rack ears are proportionally longer to permit center mounting.

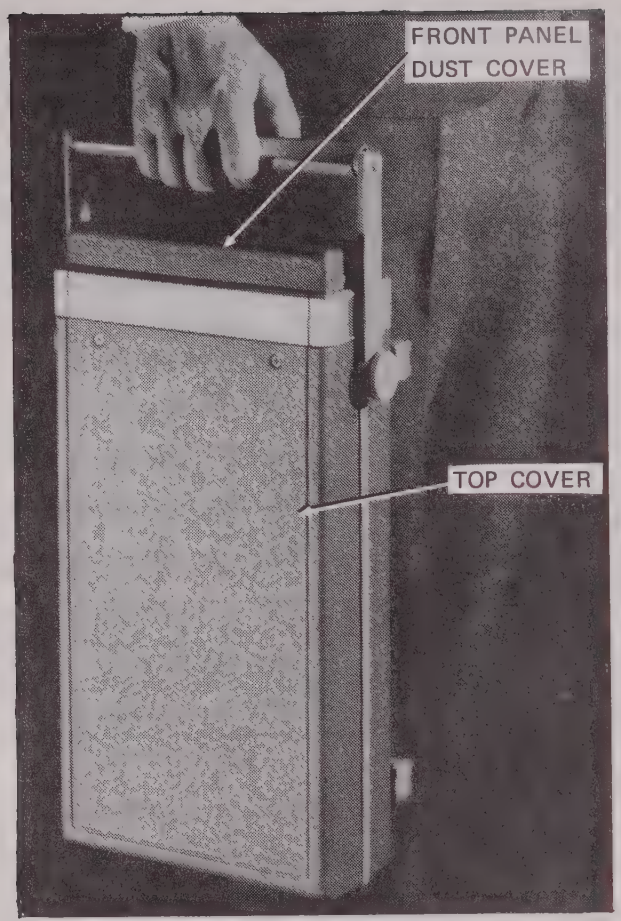


Figure 6-5. FRONT PANEL DUST AND TOP COVER

6-14. OPTION INFORMATION

6-15. Introduction

6-16. The rechargeable battery pack kit (Option 8100–01K) may be factory installed when the instrument is first purchased or it may be purchased separately and installed at a later time as a kit. The kit consists of a rechargeable battery, a ballast lamp, two resistors, three diodes, a battery condition meter and associated hardware. The following paragraphs give the field installation procedure, operating instructions, and list of replaceable parts for the battery option kit.

6-17. Installation Procedure

a. Disconnect the instrument from the line.

b. Remove the top and bottom covers, the narrow trim strips just above and below the readout tubes, and the top and bottom guards; use the procedure given in Section 4, paragraph 4-9 of the manual.

c. Install and solder the 2 ohm and 11.5k ohm resistors on the PCB at the locations shown in Figure 6-7.

CAUTION

Use a 40-watt soldering iron and non-corrosive solder on all connections.

d. Install and solder the three diodes on the PCB at the locations shown in Figure 6-7. Be sure that the diodes are oriented according to the anode-cathode markings that are etched on the PCB.

e. Install and solder the ballast lamp on the PCB at the location shown in Figure 6-7. Three solder connections are required: The anchor lug on the component side of the PCB should be soldered to the side of the lamp base once the lamp is in position, and the two lamp terminals should be soldered from the underneath side of the PCB.

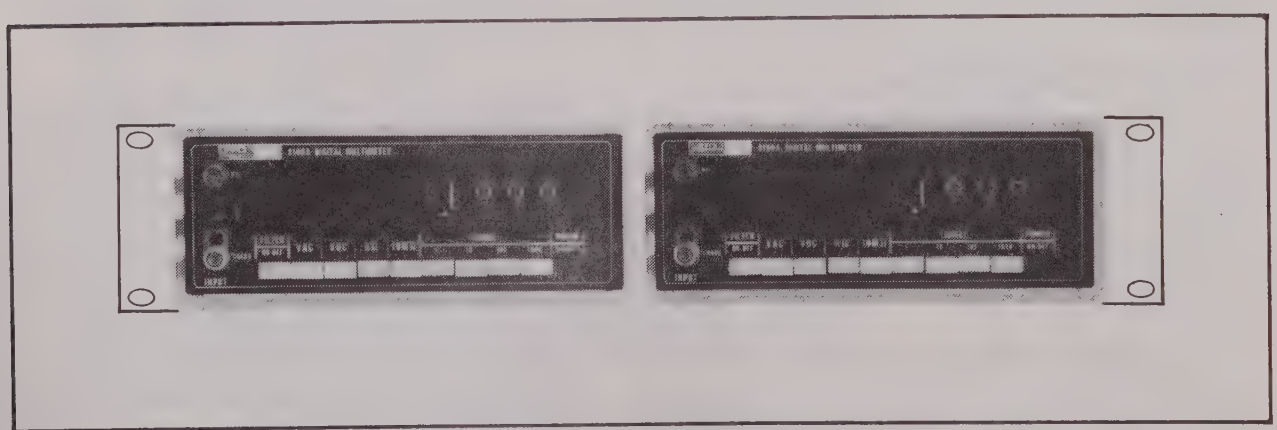


Figure 6-6. RACK MOUNT KIT

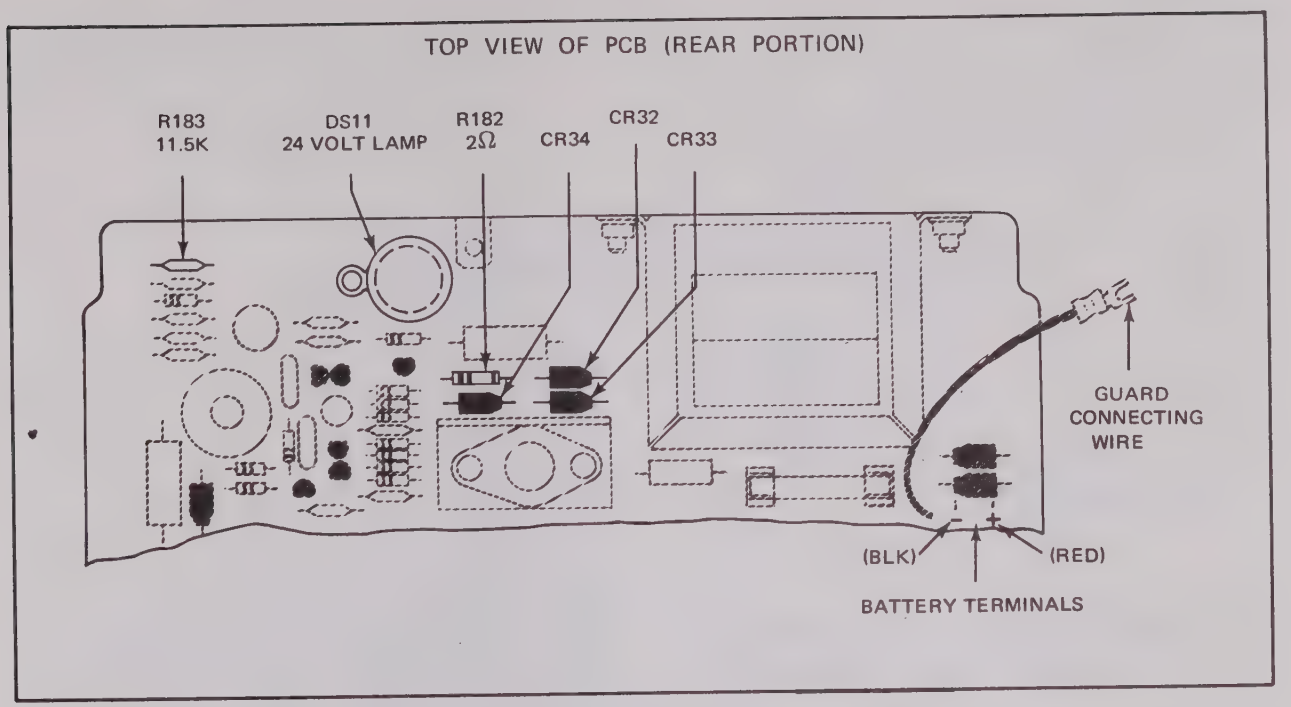


Figure 6-7. COMPONENT LOCATIONS FOR MODEL 8100A–01K BATTERY OPTION KIT INSTALLATION

f. Refer to Figure 6-8 and install the meter by performing the following steps:

1. Remove the nut and two washers which fasten the black tube cover to the inside of the front panel assembly near the INPUT terminals.

2. Remove the meter cover away from the front panel; install the meter with the meter face against the front panel.

3. Fasten the cover in place by replacing the nut and washers.

4. Bend the meter lugs toward the rear of the instrument so they are parallel with the PCB and aligned with holes in the PCB. See Figure 6-8.

5. Connect each meter lug to hole in PCB directly under parallel bent meter lugs using suitable length of tinned #22 AWG copper wire. Solder each of four connections securely in place.

g. On underside of top guard, remove shield. See Figure 6-9. Install the battery pack on the underneath side of the top guard, using the battery pack holder and the six machine screws (Figure 6-9). Orient the battery pack so the grommeted battery leads pass through the grommet hole in the edge of the guard.

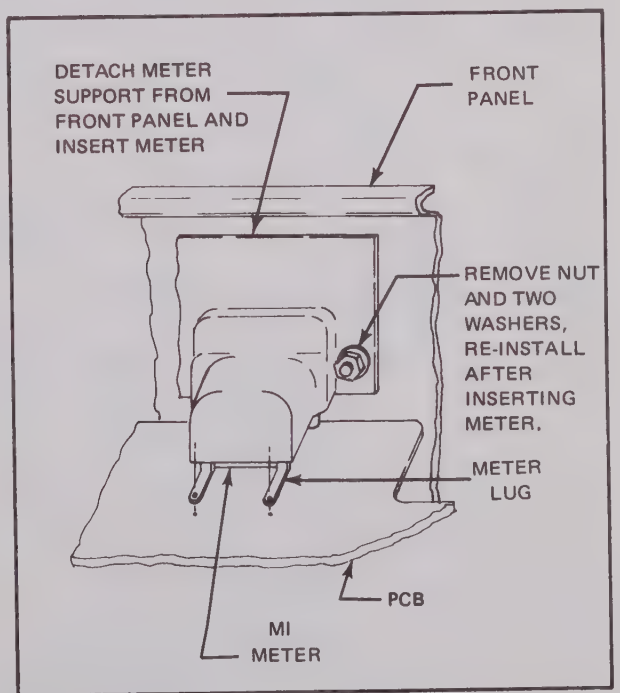


Figure 6-8. BATTERY OPTION KIT METER INSTALLATION

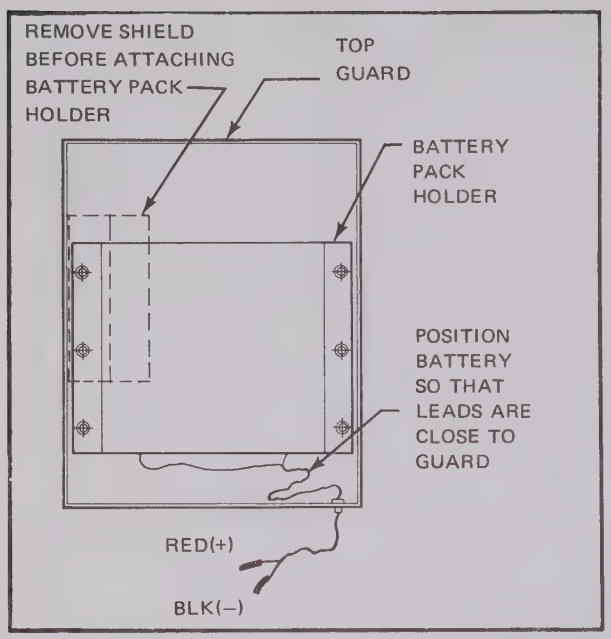


Figure 6-9. BATTERY OPTION KIT INSTALLATION

h. Replace the top guard and connect the battery leads to battery terminals at the right-rear of the PCB as shown in Figure 6-7. Red lead to + terminal and black lead to other terminal.

i. Replace the bottom guard and top and bottom covers.

6-18. Operating Instructions

6-19. The battery supplies power to the instrument when the instrument is disconnected from the line. The front panel meter monitors the charge condition of the battery during battery operation, BAT OK. During line operation, while the battery is charging, the meter indicates LINE OPR (full-scale). When fully charged, the battery will provide 8 hours of continual operation before recharging is necessary. When fully discharged, the battery requires a maximum of 10 hours of fully charge.

6-20. The ballast lamp, DS11, provides constant current charge even though line and battery levels may vary.

6-21. LIST OF REPLACEABLE PARTS

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DIGITAL MULTIMETER – KIT BATTERY OPTION 8100A–01K	296886	89536	296886	1		
BT1		Battery Pack	269837	89536	269837	1		
		Battery, rechargeable, 21.6v 18 cell	272559	06860	401578	1		
M1		Meter, 0-1 ma (See Figure 5-1)	266494	89536	266494	1		
XBT1		Holder, battery pack	269712	89536	269712	1		
CR32	E5-Z3	Diode, silicon, 1 amp, 600 piv (See Figure 5-3)	112383	05277	1N4822	2		
CR33	E5-Z2	Diode, silicon, 1 amp, 600 piv (See Figure 5-3)	112383	05277	1N4822	REF		
CR34	F5-Z2	Diode, silicon, 1 amp, 100 piv (See Figure 5-3)	116111	05277	1N4817	1		
DS11	G3-AA3	Lamp, incandescent, 24v (See Figure 5-3)	218354	08806	1252	1	2	
R182	F5-Z3	Res, comp, 2Ω ±5%, ½w (See Figure 5-3)	218735	01121	EB20G5	1		
R183	I3-AA3	Res, met flm, 11.5k ±1%, 1/8w (See Figure 5-3)	267138	91637	Type MFF 1/8	1		

OPTION INFORMATION

PRINTER OUTPUT UNIT

6-1. INTRODUCTION

6-2. The Printer Output Unit (POU) provides data output that is completely isolated from the analog input and is available in 8-4-2-1 BCD logic level format. Data is transferred serially via guarded transformers from the multimeter to the POU. Digit, range, function, filter, and overrange data are provided.

6-3. SPECIFICATIONS

6-4. Electrical Specifications

DATA PROVIDED	Digits, range, function, and filter.
CODING	BCD Digits, four lines for range, individual lines for functions and filter.
LOGIC LEVELS	"1" = 2.4V @ 0.4 ma load (3.5V maximum, open terminal)
	"0" = 0.4V maximum at 13 ma sink (0V no load)
TRIGGER DESCRIPTION	Positive or negative true triggering via two trigger channels using either a pulse or a steady state logic signal.
	Channel 1
Pulse Width	>300 ns
Transition	Logic "0" to logic "1"
Logic "1"	>2.7V @ 360 ua max.
Logic "0"	<0.6V @ no drain
Continuous Sample	Logic "1"
Input Definition	TTL (UTILOGIC II SERIES)
	Chanel 2 >300 ns
	Logic "1" to logic "0" >2.0V (4.7k pull up resistor) on input.
	<0.8V @ 3.2 ma sink
	Logic "0"
	TTL (7400 SERIES)
PRINT COMMAND	Change of state from logic "1" to logic "0" and change of state from logic "0" to logic "1" are both provided.

6-5. Mechanical Specifications

OUTPUT CONNECTOR	36-pin Amphenol 57-40360
	JF Part Number 158469
MATING CONNECTOR	36-pin Amphenol 57-30360
	JF Part Number 158451

6-6. General Specifications

Code conversion and level translation are available; contact the factory for details.

Option –02 is a factory installed option and is not compatible with battery option.

Full CMRR specifications of a line operated 8100 series digital multimeter are met. Maximum potential between printer output common and power line ground is 250V dc or peak ac.

6-7. INSTALLATION

6-8. The Printer Output Unit is a factory installed option.

6-9. OPERATING INSTRUCTIONS

6-10. Description

6-11. The POU enables the multimeter to interface with a computer, printer, or a variety of data recording systems. POU access is by means of a single rear-mounted 36-pin connector. Connector location and pin assignments are given in Figure 6-1. The unit is self-powered. POU truth table is given in Table 6-1.

Table 6-1. POU TRUTH TABLE

DATA	NO. OF LINES	LOGIC LEVEL	
		LOGIC "0" 0 TO 0.4V	LOGIC "1" 2.4 TO 3.5V
Function: VDC, VAC, KΩ, 10 MΩ, FILTERS	5	Function not called.	Function called.
Polarity (logic "0" for all functions except "+VDC")	1	Negative	Positive
Range: 1, 10, 100 and 1000	4	Range not called.	Range called.
Digits: 8-4-2-1 BCD	16	Binary "0"	Binary "1"
Overrange Digit	1	Not overranged.	*Overranged.

* 11999 readout should be interpreted as "overranged and overloaded".

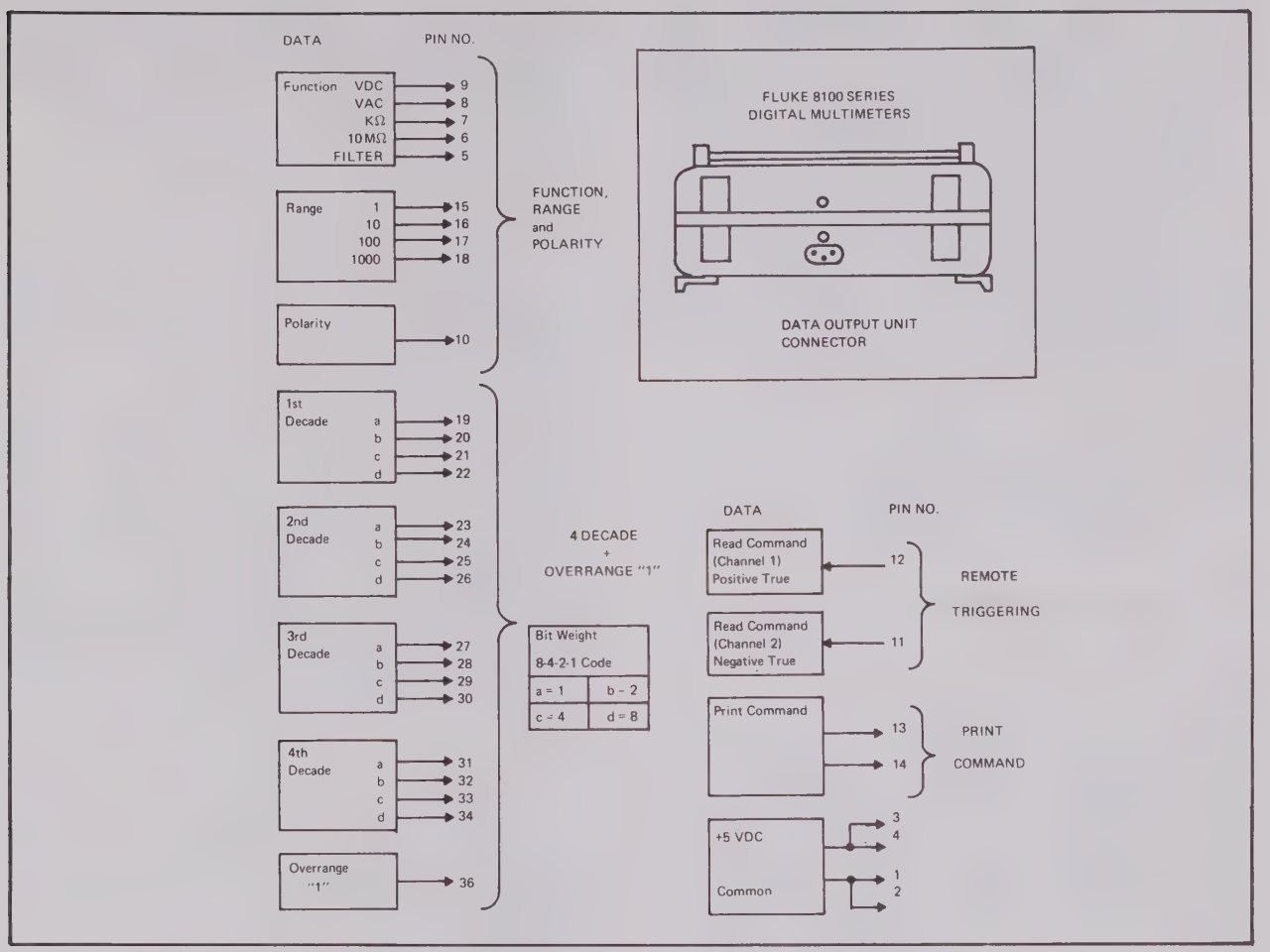


Figure 6-1. PRINTER OUTPUT UNIT CONNECTOR LOCATION AND PIN ASSIGNMENT

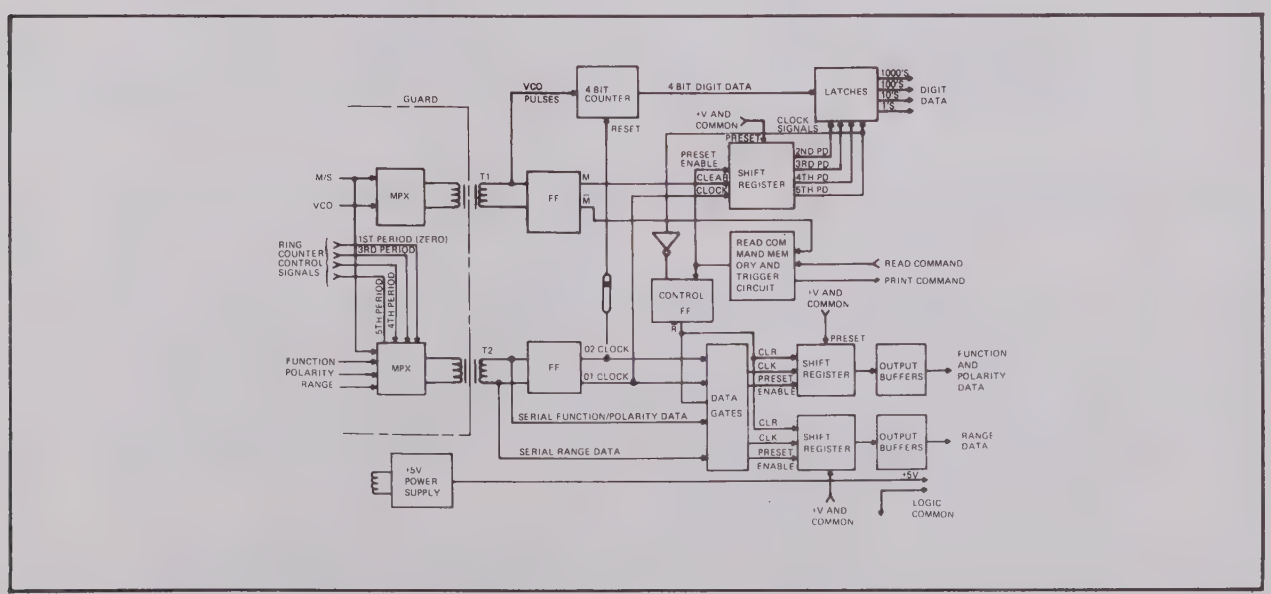


Figure 6-2. PRINTER OUTPUT UNIT BLOCK DIAGRAM

6-12. The Printer Output Unit can be triggered by either a positive true or negative true read command. The read command may be either a pulse or a steady state logic level. If triggered by a pulse, the unit will provide data derived from a sample of the multimeter input within 450 milliseconds of the read command. This data will be stored in the output register until the next read command is received. If triggered by a continuous logic level, data in the output resister will be updated approximately every 400 milliseconds, as often as the instrument makes a measurement). Characteristics of the read command signal are given in Table 6-2.

NOTE!

The measurement cycle of the instrument is not altered by the read command.

6-13. THEORY OF OPERATION

6-14. General

6-15. The Printer Output Unit accepts multimeter measurement information, multiplexes it for serial transmission through the guard and enters this data into circuitry which provides BCD (8-4-2-1) decade outputs and function, polarity, and uncoded range outputs. A digital memory, comprised of four bistable latches provides 4-line, BCD digital data. A pair of 5-bit shift registers function as a serial in-parallel out memory for multimeter function, function, polarity, and range data. The POU block diagram is shown in Figure 6-2.

6-16. Multiplexer

6-17. Multimeter function, range, polarity, and digit inputs together with logic control signals are applied to multiplexer circuitry consisting of transistors Q1 through Q13 and NOR gates A1 and A2.

6-18. VCO pulses are applied to one input of dual-input NOR gate A1–A, and the measure/store signal is applied to the other input. The VCO pulses enable the gate and its output is applied to the trigger circuit composed of Q5 and T1. The VCO pulses are coupled into the secondary of T1 (signal (1)) and applied to counter A10. Trigger pulses corresponding to the measure/store signal are produced by Q2, Q3, and Q5 in the primary of T1. The measure/store signal is reconstructed by flip-flop A4–C, D from the secondary of T1, producing M and $\overline{M}$ signals.

6-19. Multimeter clock signals, $\phi 1$ and $\phi 2$, are applied to trigger circuits Q11 and Q13, respectively. The trigger pulses are coupled into the secondary of T2 where they alternately set and reset flip-flop A4–A, B, producing reconstructed clock signals 3 and 4.

Table 6-2. READ COMMAND SIGNAL REQUIREMENTS

READ COMMAND	CHANNEL	
	1	2
TRIGGER: Pulse Width	>300 ns	>300 ns
Rise Time		
Transition	Logic "0" to logic "1"	Logic "1" to logic "0"
LOGIC LEVEL: Logic "1"	>2.7V at 360 ua max.	>2.0V (4.7k pull-up resistor) on input.
Logic "0"	<0.6V at no drain	<0.8V at 3.2 ma sink
CONTINUOUS SAMPLE	Logic "1"	Logic "0"
INPUT DEFINITION	TTL (UTILOGIC II SERIES)	TTL (7400 SERIES)

6-20. The Ø1 clock signal is also applied to a one-shot, A1–B, D. The one-shot provides a delay for entry of function and polarity data into the trigger circuit to ensure that data pulses are not obscured by clock pulses. Function inputs (KΩ, VAC, 10MΩ, and FILTer) are controlled by FET buffers Q6 through Q9, which are sequentially enabled by ring counter signals corresponding to periods 1 (zeroing period), 3, 4, and 5 of the measurement cycle. If one or more of these functions are called, a low will appear at one input of NOR gate A1–C during the appropriate period of the measurement cycle; the one-shot, which controls the other input of gate A1–C, will time out, and A1–C will provide a pulse to the trigger circuit. The polarity input is NORed with the one-shot output in A2–C and is also delayed.

6-21. The Ø2 clock signal is applied to one-shot A2–A, B to provide a delay for range inputs. Range information is derived from the readout tube decimal point circuitry and is applied to transistor Q12 in the multiplexer. Inverted range data is then applied to gate A2–D. After the prescribed delay, it enters the trigger circuit of Q13 and T2. The Printer Output Unit timing diagram is shown in Figure 6-3.

6-22. Digit Count and Memory Circuitry

6-23. Four-Bit counter A-10 accepts VCO pulses from Inverter A2-F and produces a 4-line BCD output corresponding to digit value. The counter is reset at the beginning of each digitizing period by a delayed reset pulse (signal 7), which is derived from the Ø2 clock signal. This delay duplicates the delay of the multimeter counter reset pulse so that the counters are sychronized. The reset pulse is produced by NOR gate A12–B, transistor Q4, and associated components.

6-24. The BCD output of A10, representing digit value in a 4-line code, is applied to two dual 4-bit bistable latches, A6 and A7. The latches are clocked by signals from A11, a 5-bit shift register. The clock signals appear at the input of the latches sequentially, beginning with the 2nd period of the measurement cycle. BCD information corresponding to the most significant digit is transferred to the output of the latches first and BCD outputs for the three remaining digits follow in order. The latches provide 4-line BCD storage for each digit.

6-25. Overrange indication is provided by AND gate A1–D which provides a logical "1" output whenever the first digit is 10 or more. Gates A1–A, B prevent the register from indicating greater than "9" for the first digit.

6-26. Shift register A11 is cleared at the start of the storage cycle by the M signal, setting all shift register outputs to the logical "0" state: the register remains in this state for the duration of the storage cycle. The read pulse (signal 12), developed by the read command circuit, is applied to the preset enable input of the shift register; this pulse only occurs if an external trigger has been stored in flip-flop A5–C,D prior to the M signal. The preset input sets output 15 (pin 15) of A11 to the logical "1" state. The Ø1 clock signal is applied to the clock input of the register; and the next transistion of this clock signal from logical "1" to logical "0", occurring at the start of the 2nd period, shifts the register and provides a logical "1" at output 14 (pin 14) of the register. Succeeding clock signal transisitions cause continued shift of the register until output 10 switches to the logical "1" state, which causes the read command and control flip-flops to be reset.

6-27. Read Command Memory and Trigger Circuit

6-28. Positive read command pulses or logic levels appear at pin 11 of flip-flop A5–C, D. Negative read commands appear at the same input after inversion in A2-3B. The positive input sets the flip-flop, producing a low at one input of dual input NOR gate A12–C. Circuit conditions will hold until the start of the measurement cycle, at which time the negative transition of the M signal causes A12–C to produce the read pulse (signal 12). This sets CONTROL flip-flop A5–A, B clearing A8 & A9 and enabling A3–B, A3–C and A12–D to allow transmission of Function and Range information to shift registers A8 and A9. At the end of the measure cycle, flip-flops A5–C, D A5–A, B will be reset by the output of gate A12–A, producing negative and positive print commands, and storing range and function data by disabling clock pulses. from A12–D to A8 and A9.

6-29. Function, Polarity, and Range Circuitry

6-30. Serial function and polarity data is applied to gate A3–C and serial range data is applied to gate A3–B. Each gate is controlled by one phase of the clock signal and a signal from control flip-flop A5–A, B. Function and polarity data appear as positive pulses at the preset enable input of A8 during the digitizing period (Ø1) of the clock. Range data appears as positive pulses at the preset enable input of A9 during the display period (Ø2) of the clock.

6-31. Shift registers A8 and A9 are cleared at the beginning of each measure cycle by the control flip-flop if a read pulse has been initiated. The registers are clocked at

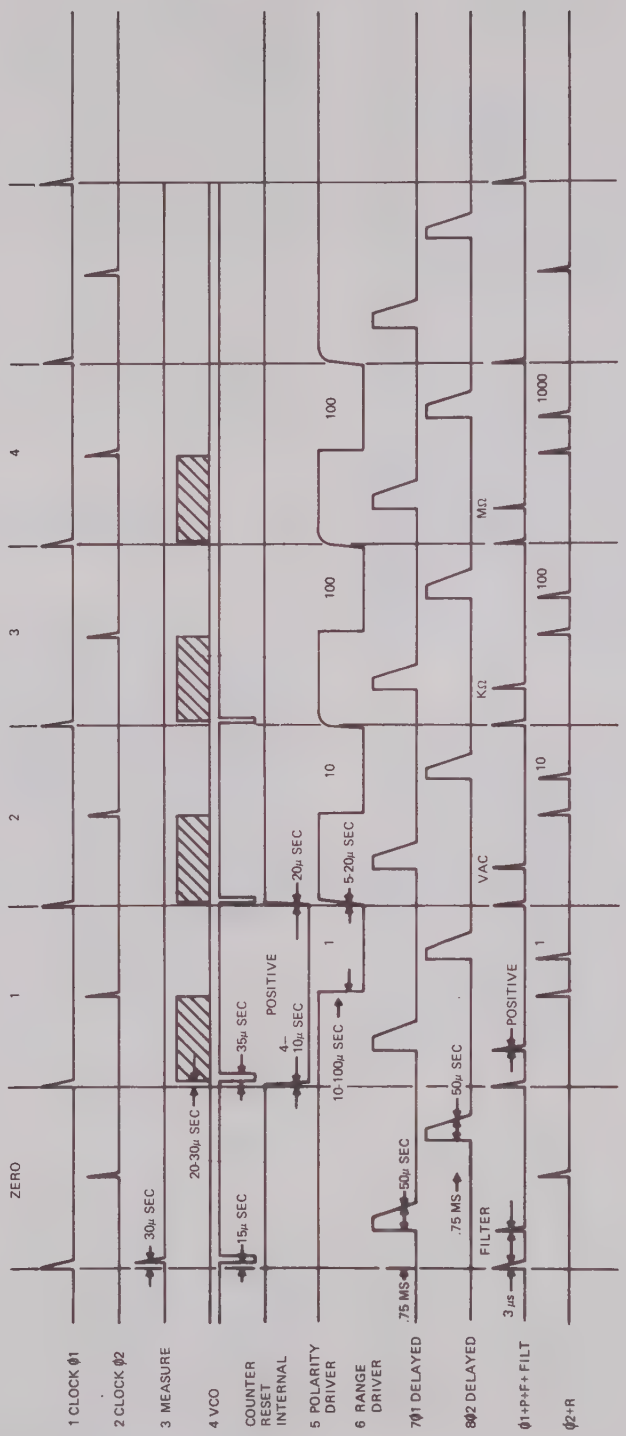


Figure 6-3. TIMING DIAGRAM

the beginning of the digitizing period of the clock by the signal from gate A12-D. Each data pulse at the input of the registers presets a logical "1" at output 15 of the registers and the clock pulses shift the registers five times each measure cycle, resulting in correct data positions at the output.

6-32. AND gates A13, and A14 are output buffer gates. NOR gate A3–A provides a logical "1" output when VDC function is called; it also enables AND gate A1–C for polarity indication.

6-33. MAINTENANCE

6-34. General

6-35. General maintenance information, such as factory service and instrument cleaning procedures, is covered in Section 4 of the manual. The following information covers service procedures peculiar to the POU.

6-36. Access/Disassembly

6-37. POU circuitry is located on two separate PCBs. The POU Output Assembly PCB contains all POU circuitry located outside the multimeter guard and the POU Encoder Assembly contains all POU circuitry located inside the guard. The following procedure should be used to gain access to POU circuitry (Refer to Figure 6-4.):

a. To gain access to the POU Output Assembly, remove the top dust cover. The assembly is mounted to the top of the guard chassis.

b. To gain access to the POU Encoder Assembly, remove the four guard chassis mounting screws located on the side rails and carefully lift the guard chassis out of the multimeter to the extent permitted by the POU wiring. The POU Encoder Assembly is mounted on the underneath side of the guard chassis.

c. To replace components on either PCB, remove the PCB mounting hardware to gain access to the soldered side of the board.

6-38. POU/Multimeter Wiring

6-39. All POU/Multimeter connections are made with pin connectors. The wires are color coded and the coding is indicated on the wiring diagram so that leads which are disconnected may be replaced correctly.

6-40. Test Equipment

6-41. Equipment required for testing, troubleshooting, and calibration of the POU is given in Table 6-3.

Table 6-3. TEST EQUIPMENT

EQUIPMENT NOMENCLATURE	RECOMMENDED EQUIPMENT	FUNCTION
DC Voltage Source	Fluke Model 343A DVM Calibrator	Performance Tests and Troubleshooting
DC Voltmeter	Model 8100A Digital Multimeter	Troubleshooting
Oscilloscope	Tektronix Type 545A Oscilloscope with Type 1A1 Dual Trace Plug-In	Troubleshooting

6-42. Performance Tests

6-43. Correct operation of the Printer Output Unit can be verified by applying various inputs to the multimeter and observing the POU outputs on a printer or other recording device. Refer to Section II of the manual for operating instructions and equipment connections.

6-44. Troubleshooting

6-45. Before attempting to troubleshoot the unit, it should be verified that the trouble is actually in the POU and is not caused by faulty external equipment. As a first step, the POU should be exercised as described in "Performance Tests" to determine what fault is present. Once the fault is identified, consult the troubleshooting guide, Figure 6-5, as an aid in making a troubleshooting decision.

6-46. Check POU waveforms with an oscilloscope. Sync the scope with the Ø2 clock signal. Refer to the POU timing diagram, Figure 6-3, for correct signal timing.

6-47. CALIBRATION

6-48. No calibration is required in the POU.

6-49. PARTS LIST

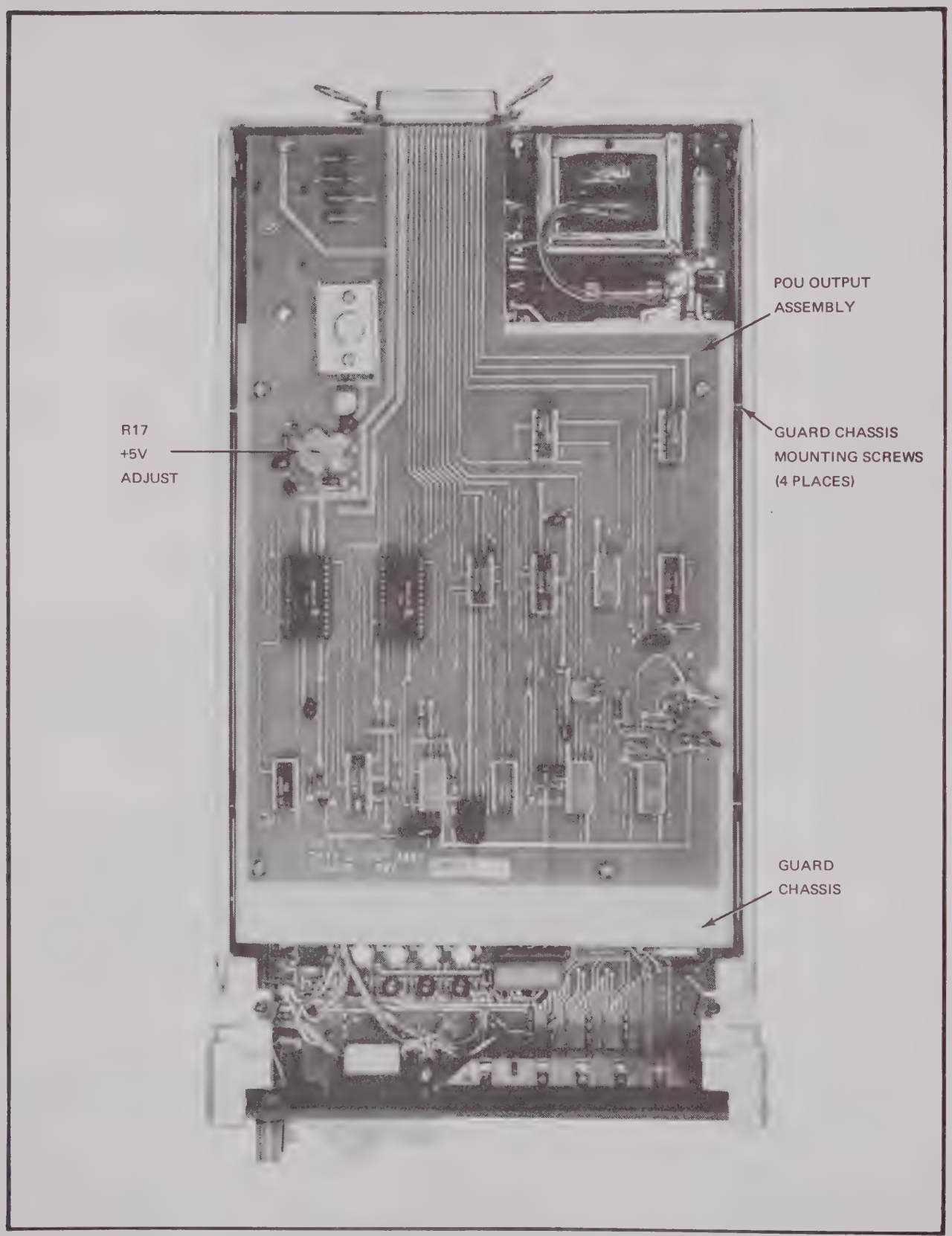


Figure 6-4. PRINTER OUTPUT UNIT PCB LOCATION (Sheet 1)

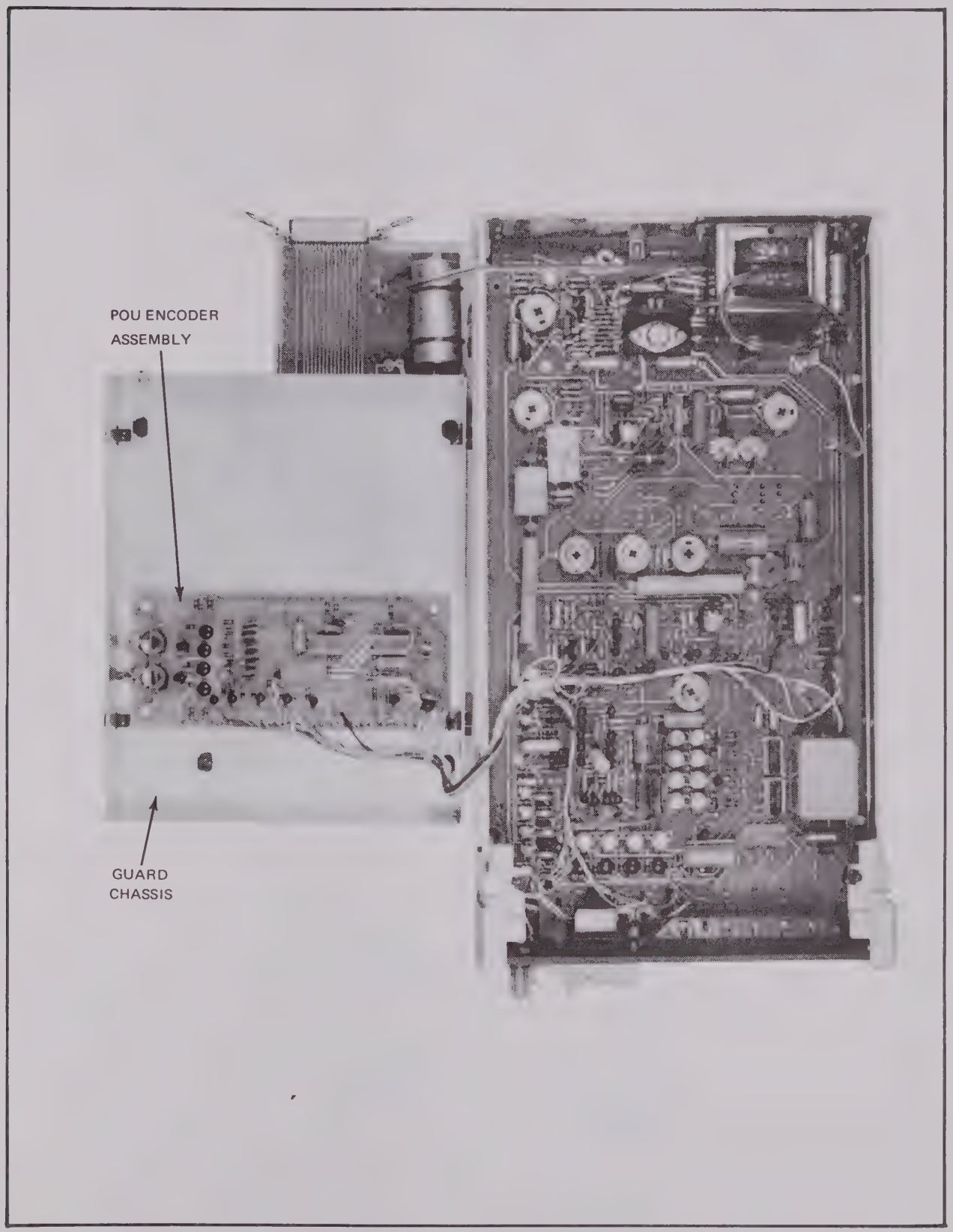


Figure 6-4. PRINTER OUTPUT UNIT PCB LOCATION (Sheet 2)

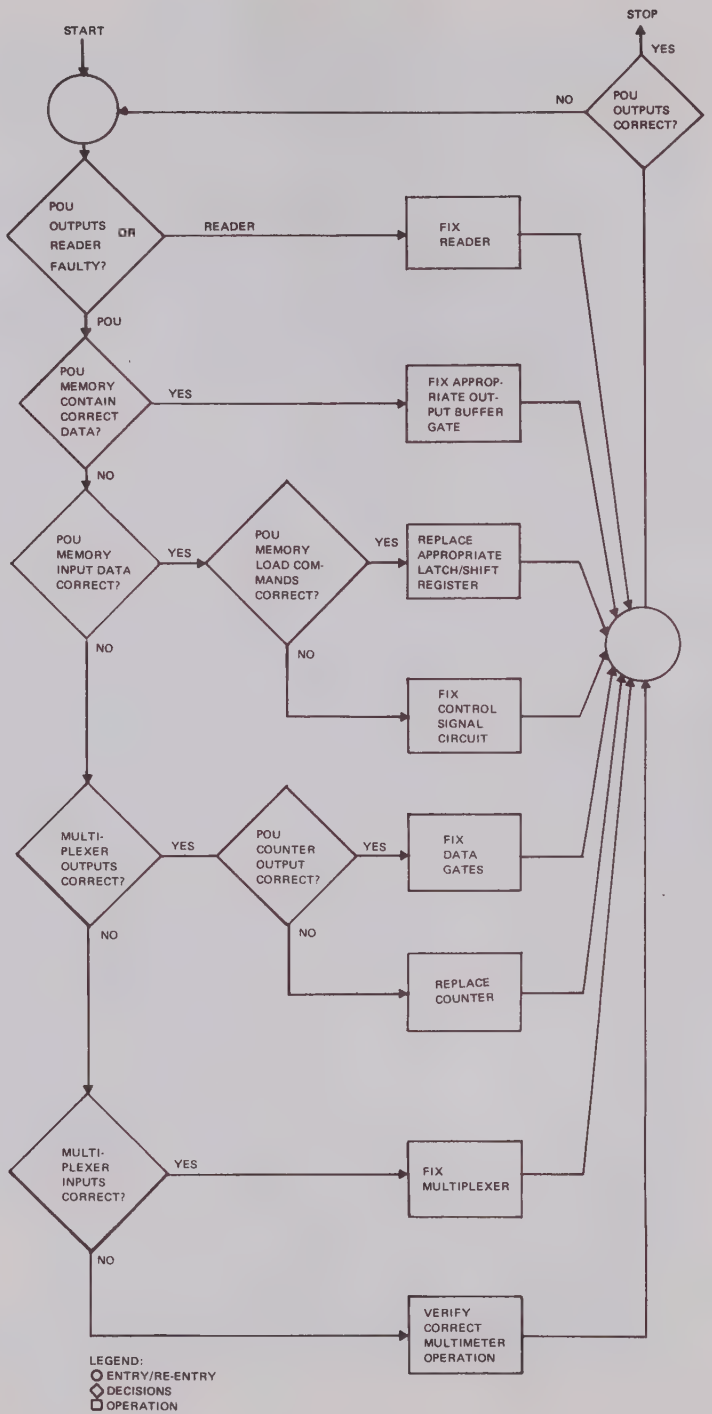


Figure 6-5. POU TROUBLESHOOTING GUIDE

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DIGITAL MULTIMETER–ISOLATED PRINTER OUTPUT OPTION	8100A-02					
		CHANGE:						
T101		Transformer, power from:	275354	89536	275354	1		
		to:	295881	89536	295881	1		
		ADD:						
A2		DATA OUTPUT PCB ASSEMBLY (See Figure 6-6)	295808	89536	295808	1		
A3		DATA OUTPUT ENCODER PCB ASSEMBLY (See Figure 6-7)	294793	89536	294793	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A2		DATA OUTPUT PCB ASSEMBLY Figure 6-6	295808	89536	295808	REF		
A1	E1-01	IC, TTL, Quad 2-Input + AND Gates	292987	01295	SN7408N	3		
A2	B5-02	IC, TTL, Hex Inverter	292979	01295	SN7404N	1		
A3	E1-P3	IC, TTL, Triple 3-Input Nor Gate	268565	18324	SP370A	1		
A4	B5-P5	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	3		
A5	B5-P1	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	REF		
A6	D5-N2	IC, TTL, 8-Bit Latch	288837	01295	SN74100N	2		
A7	D5-M1	IC, TTL, 8-Bit Latch	288837	01295	SN74100N	REF		
A8	E1-04	IC, TTL, 5-Bit Shift Register	293399	01295	SN7496N	3		
A9	E1-Q1	IC, TTL, 5-Bit Shift Register	293399	01295	SN7496N	REF		
A10	B5-L5	IC, DTL, Binary Counter	267153	04713	MC839P	1		
A11	B5-M4	IC, TTL, 5-Bit Shift Register	293399	01295	SN7496N	REF		
A12	B5-N3	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	REF		
A13	F4-O4	IC, TTL, Quad 2-Input + AND Gates	292987	01295	SN7408N	REF		
A14	F4-Q1	IC, TTL, Quad 2-Input + AND Gates	292987	01295	SN7408N	REF		
C1	B2-N3	Cap, mica, 5600 pf ±2%, 500V	182873	14655	CD19F562G	2		
C2	B3-N5	Cap, mica, 5600 pf ±2%, 500V	182873	14655	CD19F562G	REF		
C3	C3-N1	Cap, plstc, 0.022 uf ±10%, 250V	234484	73445	C280AE/A22K	3		
C4	B4-N2	Cap, cer, 0.0012 uf ±10%, 500V	106732	71590	CF122	2		
C5	C5-P2	Cap, cer, 0.0012 uf ±10%, 500V	106732	71590	CF122	REF		
C6	D3-P5	Cap, mica, 220 pf ±5%, 500V	170423	14655	CD15F221J	1		
C7	C3-P5	Cap, plstc, 0.022 uf ±10%, 250V	234484	73445	C280AE/A22K	REF		
C8	C4-P4	Cap, plstc, 0.022 uf ±10%, 250V	234484	73445	C280AE/A22K	REF		
C9	H4-L5	Cap, elect, 3800 uf +75/-10%, 15V (mounted on back)	276758	56289	196D106X0015	1		
C10	F4-M3	Cap, Ta, 10 uf ±20%, 15V	193623	56289	196D106X0015	5		
C11	E5-05	Cap, Ta, 10 uf ±20%, 15V	193623	56289	601D388G015JL4	REF		
C12	C4-M1	Cap, Ta, 10 uf ±20%, 15V	193623	56289	196D106X0015	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C14	E2-Q2	Cap, cer, 0.01 uf ±20%, 100V	149153	56289	C023B101F103M	2		
C15	C1-O5	Cap, mica, 100 pf ±5%, 500V	148494	14655	CD15F101J	1		
C16	B4-N1	Cap, cer, 0.01 uf ±20%, 100V	149153	56289	C023B101F103M	REF		
C17	F3-L5	Cap, Ta, 10 uf ±20%, 15V	193623	56289	196D106X0015	REF		
C18	C3-P1	Cap, Ta, 10 uf ±20%, 15V	193623	56289	196D106X0015	REF		
CR1	C4-Q1	Diode, germanium, 80 ma, 100 piv	149187	93332	IN270	5		
CR2	C2-Q2	Diode, germanium, 80 ma, 100 piv	149187	93332	IN270	REF		
CR3	C4-Q3	Diode, germanium, 80 ma, 100 piv	149187	93332	IN270	REF		
CR4	D1-Q3	Diode, germanium, 80 ma, 100 piv	149187	93332	IN270	REF		
CR5	B4-O5	Diode, germanium, 80 ma, 100 piv	149187	93332	IN270	REF		
CR6	I4-M2	Diode, silicon, 1 amp, 100 piv	116111	05277	IN4817	4		
CR7	I2-M2	Diode, silicon, 1 amp, 100 piv	116111	05277	IN4817	REF		
CR8	I4-M2	Diode, silicon, 1 amp, 100 piv	116111	05277	IN4817	REF		
CR9	I3-M2	Diode, silicon, 1 amp, 100 piv	116111	05277	IN4817	REF		
CR10	F2-M2	Diode, zener, 3.9V	113316	07910	IN748	1		
J1	J2-N3	Connector, female, 36 contact	158469	02660	57-40360	1		
Q1	H3-M4	Tstr, silicon, NPN (mounted on back)	288381	95303	40372	1		
Q2	G1-M3	Tstr, silicon, NPN	150359	95303	2N3053	1		
Q3	F2-L5	Tstr, silicon, NPN	168708	03508	2N3391	1		
Q4	B4-M2	Tstr, silicon, NPN	218396	04713	2N3904	1		
R1	C2-P5	Res, comp, 240 Ω ±5%, ¼w	221895	01121	CB2415	4		
R2	C3-Q3	Res, comp, 240 Ω ±5%, ¼w	221895	01121	CB2415	REF		
R3	D2-Q2	Res, comp, 240 Ω ±5%, ¼w	221895	01121	CB2415	REF		
R4	C4-Q2	Res, comp, 240 Ω ±5%, ¼w	221895	01121	CB2415	REF		
R5	B5-M1	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	4		
R6	C1-N5	Res, comp, 3.3k ±5%, ¼w	148056	01121	CB3325	1		
R7	C4-N3	Res, comp, 3.9k ±5%, ¼w	148064	01121	CB3925	1		
R8	C4-P2	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	2		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R9	C4-O5	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	REF		
R10	D1-O4	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	1		
R11	D1-O5	Res, comp, 15k ±5%, ¼w	148114	01121	CB1535	1		
R12	D4-Q2	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	3		
R13	C2-P5	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R14	C4-P3	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R15	F5-L5	Res, comp, 2k ±5%, ¼w	202879	01121	CB2025	3		
R16	G2-M3	Res, comp, 5.6k ±5%, ¼w	148080	01121	CB5625	2		
R17	F3-M2	Res, var, comp, 1k ±30%, ¼w	281642	71450	Type U201	1		
R18	F1-M1	Res, met flm, 182 Ω ±1%, 1/8w	200030	91637	RN55D1820F	1		
R19	B5-M2	Res, comp, 2k ±5%, ¼w	202879	01121	CB2025	REF		
R20	C1-N1	Res, comp, 5.6k ±5%, ¼w	148080	01121	CB5625	REF		
R21	D1-P2	Res, comp, 8.2k ±5%, ¼w	160796	01121	CB8225	1		
R22	D4-Q1	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R23	B5-O5	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R24	C3-N4	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R25	F4-L5	Res, comp, 2k ±5%, ¼w	202879	01121	CB2025	REF		
R27	B2-N1	Res, comp, 1.5k ±5%, ¼w	148031	01121	CB1525	1		
R28	B2-M3	Res, var, ww, 1k ±20%, 1¼w	111575	71450	Type 110	1		
		Socket, IC, 14 contact	276527	23880	TSA-2900-14W	9		
		Socket, IC, 16 contact	276535	23880	TSA-2900-16W	3		
		Socket, IC, 24 contact	292946	71785	24 DIP	2		

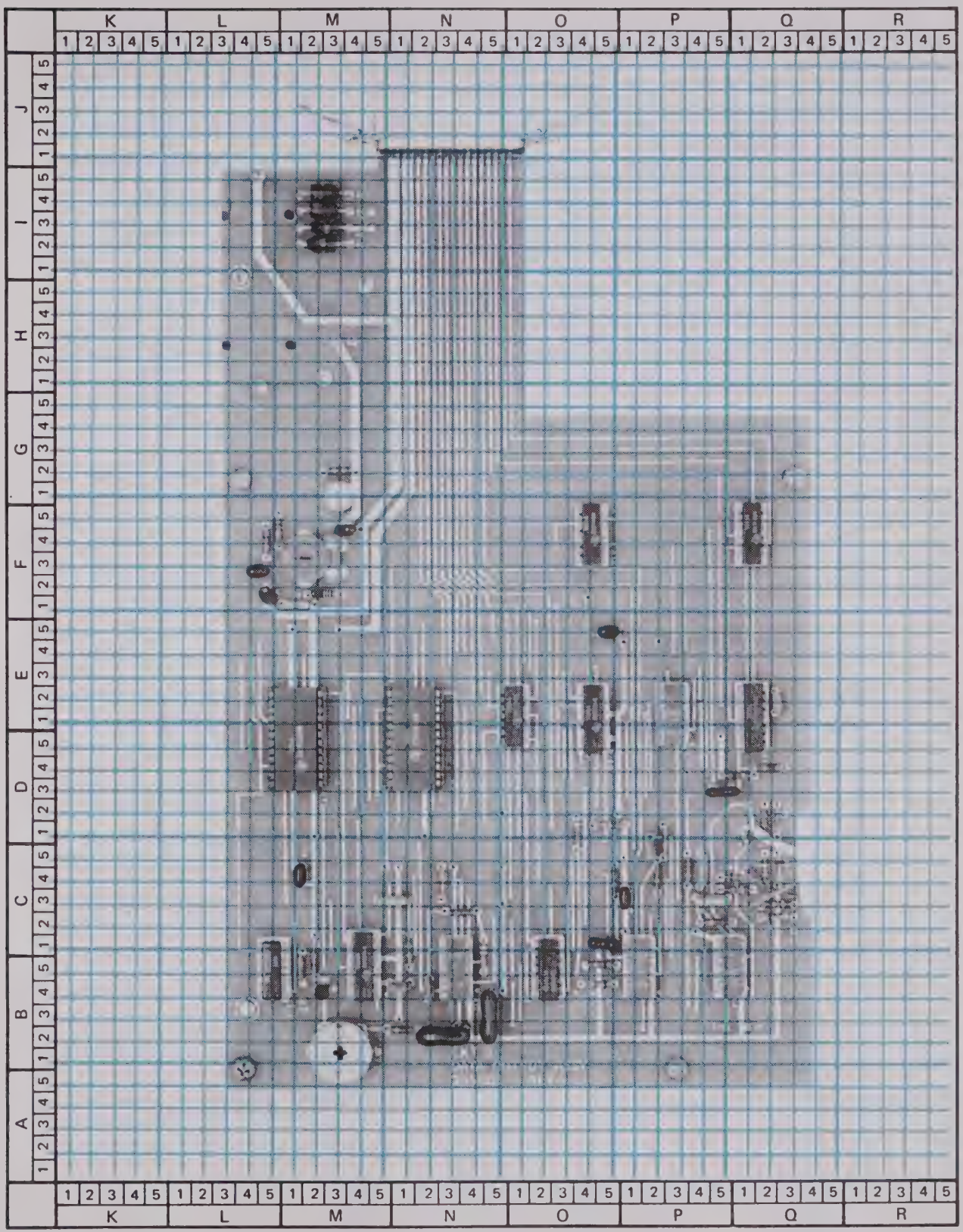


Figure 6-6. DATA OUTPUT PCB ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A3		DATA OUTPUT ENCODER PCB ASSEMBLY Figure 6-7	294793	89536	294793	REF		
A1	E1-O3	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	2		
A2	C1-O3	IC, TTL, Quad 2-Input Nor Gate	268540	18324	SP380A	REF		
C1	A5-M5	Cap, Ta, 10 uf ±20%, 15V	193623	56289	196D106X0015	3		
C2	G4-N3	Cap, cer, 0.0012 uf ±10%, 500V	106732	71590	CF122	8		
C3	G2-N4	Cap, cer, 0.0012 uf ±10%, 500V	106732	71590	CF122	REF		
C4	G1-N5	Cap, cer, 0.0012 uf ±10%, 500V	106732	71590	CF122	REF		
C5	D2-P2	Cap, cer, 0.01 uf ±20%, 100V	149153	56289	C023B101F103M	2		
C6	E5-O4	Cap, plstc, 0.22 uf ±10%, 80V	159392	56289	192P2249R8	2		
C7	D5-O5	Cap, cer, 0.05 uf ±20%, 100V	149161	56289	55C23A1	3		
C8	G2-O5	Cap, cer, 0.0012 uf ±10%, 500V	106732	71590	CF122	REF		
C9	G2-04	Cap, cer, 0.0012 uf ±10%, 500V	106732	71590	CF122	REF		
C10	G2-P1	Cap, cer, 0.0012 uf ±10%, 500V	106732	71590	CF122	REF		
C11	A5-N2	Cap, cer, 0.05 uf ±20%, 100V	149161	56289	55C23A1	REF		
C12	B3-N5	Cap, cer, 0.01 uf ±20%, 100V	149153	56289	C023B101F103M	REF		
C13	C2-N5	Cap, plstc, 0.22 uf ±10%, 80V	159392	56289	192P2249R8	REF		
C14	B5-O5	Cap, cer, 0.05 uf ±20%, 100V	149161	56289	55C23A1	REF		
C15	G2-O3	Cap, cer, 0.0012 uf ±10%, 500V	106732	71590	CF122	REF		
C16	G2-O1	Cap, cer, 0.0012 uf ±10%, 500V	106732	71590	CF122	REF		
C17	I1-N3	Cap, Ta, 10 uf ±20%, 15V	193623	56289	196D106X0015	REF		
C18	I1-O4	Cap, Ta, 10 uf ±20%, 15V	193623	56289	196D106X0015	REF		
CR1	I2-M3	Diode, silicon, 150 ma	203323	03508	DHD1105	6		
CR2	H5-M3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR3	C5-N1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR4	H2-P3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
CR5	C3-N1	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR6	H4-P3	Diode, silicon, 150 ma	203323	03508	DHD1105	REF		
Q1	H2-M5	Tstr, FET, N-channel	288324	15818	U1994E	6		
Q2	H3-N4	Tstr, silicon, NPN	182196	07263	2N3643	4		
Q3	F3-N4	Tstr, silicon, NPN	218396	04713	2N3904	3		
Q5	H3-N1	Tstr, silicon, NPN	182196	07263	2N3643	REF		
Q6	E2-M5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q7	F1-M5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q8	F5-M5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q9	G4-M5	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q10	B5-N1	Tstr, FET, N-channel	288324	15818	U1994E	REF		
Q11	H3-O5	Tstr, silicon, NPN	182196	07263	2N3643	REF		
Q12	B1-O3	Tstr, silicon, NPN	218396	04713	2N3904	REF		
Q13	H3-O2	Tstr, silicon, NPN	182196	07263	2N3643	REF		
Q14	H3-M4	Tstr, silicon, NPN	218396	04713	2N3904	REF		
R1	H1-N2	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	3		
R2	G5-N4	Res, comp, 470 Ω ±5%, ¼w	147983	01121	CB4715	1		
R3	I3-M3	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	11		
R4	I1-N5	Res, comp, 47 Ω ±5%, ¼w	147892	01121	CB4705	4		
R5	F4-N2	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R6	G1-N3	Res, comp, 1.2k ±5%, ¼w	190371	01121	CB1225	2		
R11	G4-N5	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R12	I1-M3	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R13	I1-N2	Res, comp, 47 Ω ±5%, ¼w	147892	01121	CB4705	REF		
R14	C4-N3	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R15	E3-N1	Res, comp, 20k ±5%, ¼w	221614	01121	CB2035	4		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R16	F2-N1	Res, comp, 20k ±5%, ¼w	221614	01121	CB2035	REF		
R17	G1-N1	Res, comp, 20k ±5%, ¼w	221614	01121	CB2035	REF		
R18	G3-N1	Res, comp, 20k ±5%, ¼w	221614	01121	CB2035	REF		
R19	D5-P3	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R20	C4-N1	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	2		
R21	D5-N5	Res, comp, 6.8k ±5%, ¼w	148098	01121	CB6825	2		
R22	D5-P1	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	2		
R23	G5-O5	Res, comp, 750 Ω ±5%, ¼w	218024	01121	CB7515	2		
R24	G5-O4	Res, comp, 910 Ω ±5%, ¼w	203851	01121	CB9115	1		
R25	B4-N2	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R26	G5-P1	Res, comp, 750 Ω ±5%, ¼w	218024	01121	CB7515	REF		
R27	H3-P3	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R28	I1-O5	Res, comp, 47 Ω ±5%, ¼w	147892	01121	CB4705	REF		
R29	B3-O4	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R30	B2-O1	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R31	C2-N1	Res, comp, 2.2k ±5%, ¼w	148049	01121	CB2225	REF		
R32	C2-N4	Res, comp, 6.8k ±5%, ¼w	148098	01121	CB6825	REF		
R33	C3-O5	Res, comp, 2.7k ±5%, ¼w	170720	01121	CB2725	REF		
R34	G5-O3	Res, comp, 1k ±5%, ¼w	148023	01121	CB1025	REF		
R35	G5-O1	Res, comp, 1.2k ±5%, ¼w	190371	01121	CB1225	REF		
R36	H5-P3	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
R37	I1-O2	Res, comp, 47 Ω ±5%, ¼w	147892	01121	CB4705	REF		
R38	E1-P3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	2		
R39	C2-P3	Res, comp, 10k ±5%, ¼w	148106	01121	CB1035	REF		
R40	G5-N1	Res, comp, 4.7k ±5%, ¼w	148072	01121	CB4725	REF		
T1	I5-N2	Transformer, pulse	275362	01121	275362	2		
T2	I5-O2	Transformer, pulse	275362	01121	275362	REF		
		Socket, IC, 14 contact	276527	23880	TSA-2900-14W	2		

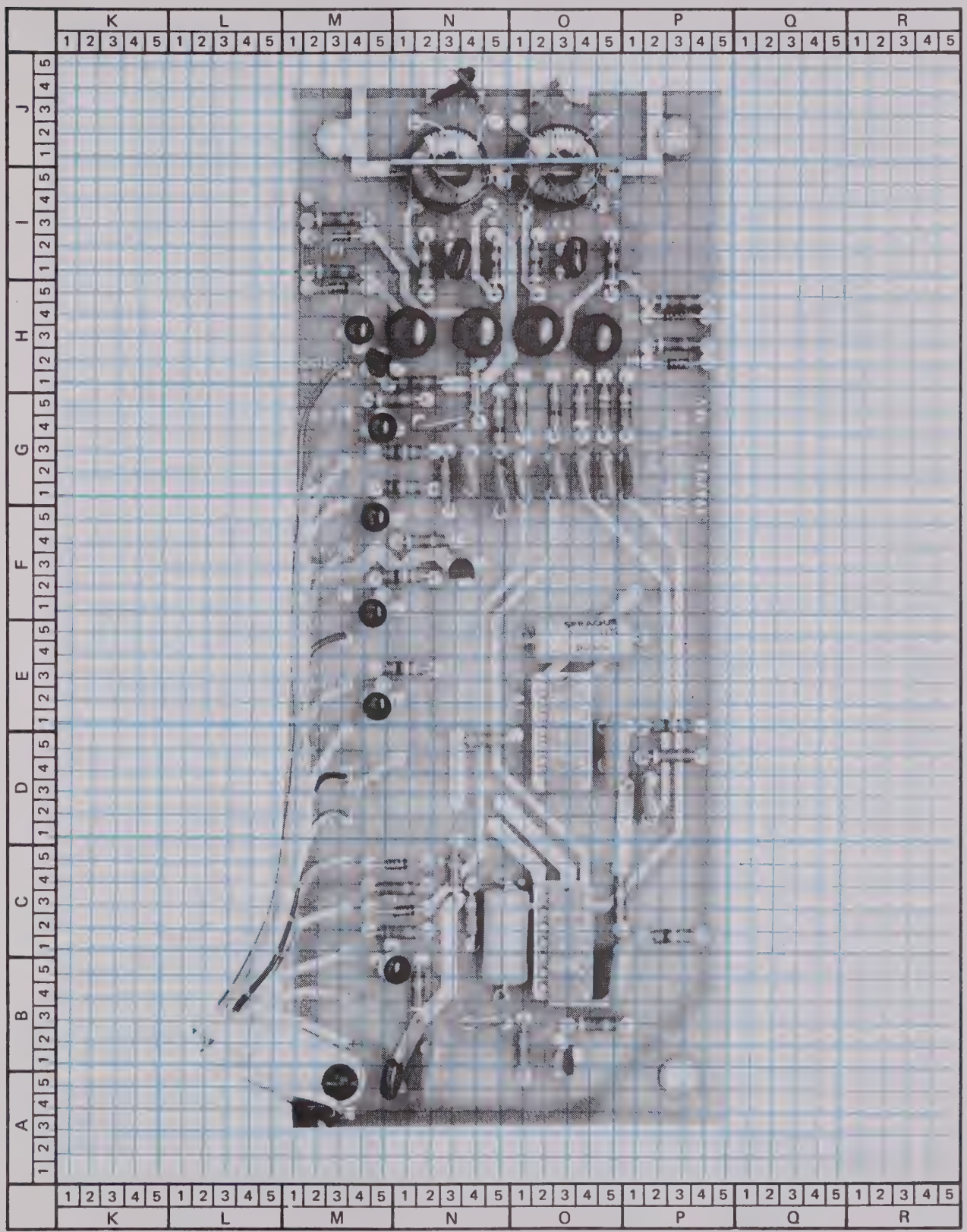
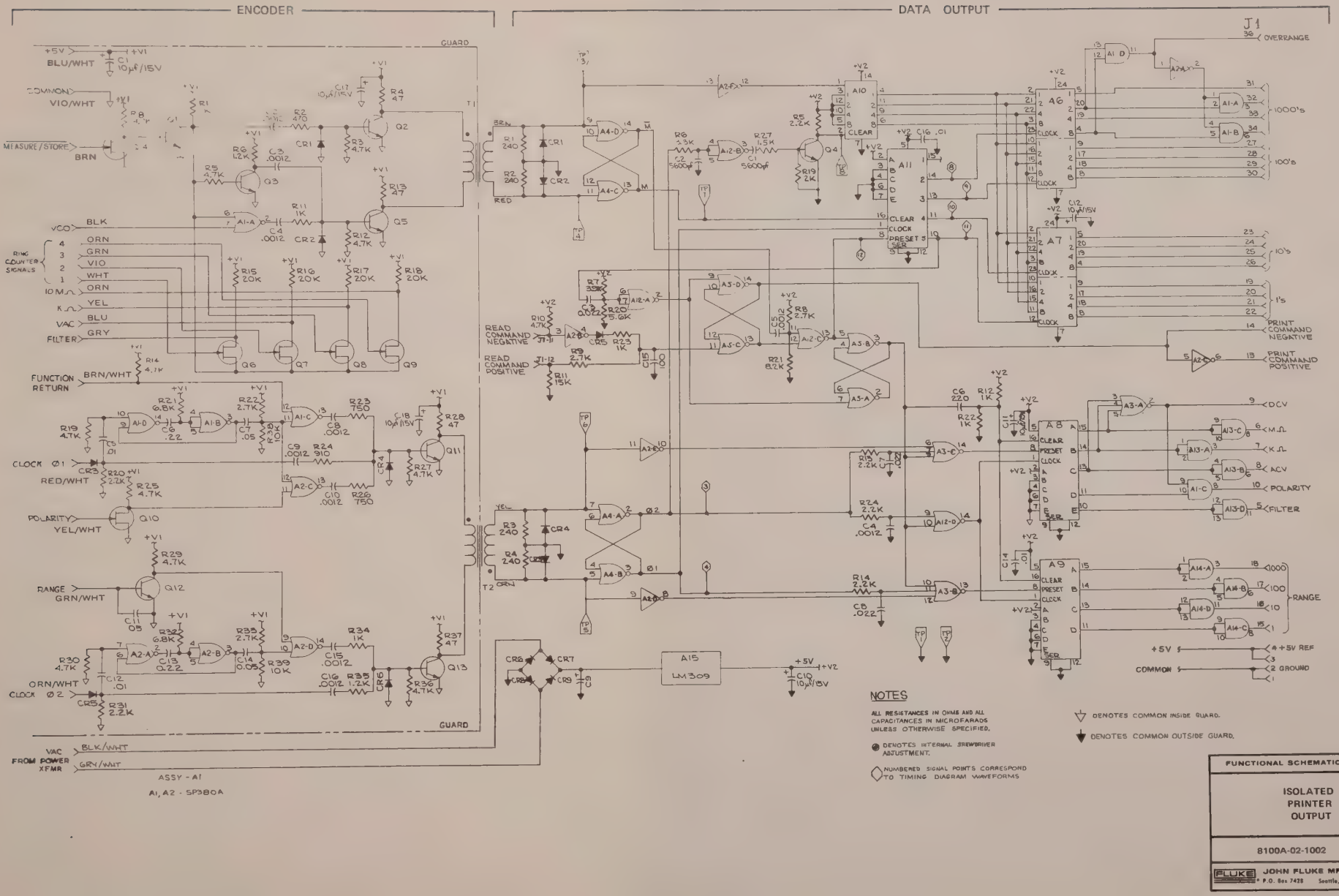


Figure 6-7. DATA OUTPUT ENCODER PCB ASSEMBLY



FUNCTIONAL SCHEMATIC DIAGRAM	
ISOLATED PRINTER OUTPUT	
8100A-02-1002	REV. 8
FLUKE JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133	

Appendix A

Federal Supply Code for Manufacturers

A-1. CODE TO NAME

A-2. The following five-digit code numbers are listed in numerical sequence along with the manufacturer's name and address to which the code has been assigned. The Federal Supply Code has been taken from Cataloging Handbook H 4-2, Code to Name.

00213 Sage Electronics Corp.
Rochester, New York

00327 Welwyn International, Inc.
Westlake, Ohio

00656 Aerovox Corp.
New Bedford, Massachusetts

00779 AMP Inc.
Harrisberg, Pennsylvania

01121 Allen-Bradley Co.
Milwaukee, Wisconsin

01281 TRW Semiconductors
Lawndale, California

01295 Texas Instruments, Inc.
Semiconductor Components Div.
Dallas, Texas

01686 RCL Electronics Inc.
Manchester, New Hampshire

01730 Deleted

01884 Dearborn Electronics Inc.
Orlando, Florida

02114 Ferroxcube Corp.
Saugerties, New York

02606 Replaced by 15801

02660 Amphenol-Borg Elect. Corp.
Broadview, Illinois

02799 Arco Capacitors, Inc.
Los Angeles, California

03614 Replaced by 71400

03651 Replaced by 44655

03797 Eldema Corp.
Compton, California

03877 Transitron Electronic Corp.
Wakefield, Massachusetts

03888 Pyrofilm Resistor Co., Inc.
Cedar Knolls, New Jersey

03911 Clairex Corp.
New York, New York

03980 Muirhead Instruments, Inc.
Mountainside, New Jersey

04009 Arrow Hart and Hegemen
Electronic Company
Hartford, Connecticut

04062 Replaced by 72136

04202 Replaced by 81312

04217 Essex Wire Corp.
Wire & Cable Div.
Anaheim, California

04221 Aemco
Div. of Midtex Inc.
Mankato, Minnesota

04645 Replaced by 75376

04713 Motorola Semiconductor
Products Inc.
Phoenix, Arizona

05082 Replaced by 94154

05236 Jonathan Mfg. Co.
Fullerton, California

05277 Westinghouse Electric Corp.
Semiconductor Dept.
Youngwood, Pennsylvania

05278 Replaced by 43543

05279 Southwest Machine and Plastic Co.
505 S. Vermont Ave.
Glendora, California

05397 Union Carbide Corp.
Electronics Div.
Cleveland, Ohio

05571 Sprague Electric Co.
Pacific Div.
Los Angeles, California

05704 Alac, Inc.
Glendale, California

05820 Wakefield Engineering Ind.
Wakefield, Massachusetts

06001 General Electric Company
Capacitor Department
Irmo, South Carolina

06136 Replaced by 63743

06473 Amphenol Space & Missle Sys.
Chatsworth, California

06555 Beede Electrical Instrument Co.
Penacook, New Hampshire

06739 Electron Corp.
Littletown, Colorado

06743 Clevite Corp.
Cleveland, Ohio

06751 Semcor Div. Components
Phoenix, Arizona

06860 Gould National Batteries Inc.
City of Industry, California

06980 Eitel-McCullough, Inc.
San Carlos, California

07115 Replaced by 14674

07138 Westinghouse Electric Corp.
Electronic Tube Div.
Elmira, New York

07263 Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344 Bircher Co., Inc.
Rochester, New York

07792 Lerma Engineering Corp.
Northampton, Massachusetts

07910 Continental Device Corp.
Hawthorne, California

08530 Reliance Mica Corp.
Brooklyn, New York

08792 CBS Electronics Semiconductor
Operations-Div. of CBS Inc.
Lowell, Massachusetts

08806 General Electric Co.
Miniature Lamp Dept.
Cleveland, Ohio

08863 Nylomatic Corp.
Norrisville, Pennsylvania

08988 Skottie Electronics Inc.
Archbald, Pennsylvania

09353 Cand K Components Inc.
Watertown, Massachusetts

09922 Burndy Corp.
Norwalk, Connecticut

11236 CTS of Berne, Inc.
Berne, Indiana

11237 Chicago Telephone of Calif. Inc.
South Pasadena, California

11358 CBS Electronics
Div. of CBS Inc.
Newburyport, Massachusetts

11403 Best Products Co.
Chicago, Illinois

11503 Keystone Mfg.
Div. of Avis Industrial Corp.
Warren, Michigan

12014 Chicago Rivet & Machine Co.
Bellwood, Illinois

12040 National Semiconductor Corp.
Danburry, Connecticut

12060 Diodes, Inc.
Chatsworth, California

12136 Philadelphia Handle Co.
Camden, New Jersey

12323 Presin Co., Inc.
Shelton, Connecticut

12327 Freeway Washer & Stamping Co.
Cleveland, Ohio

12400 Replaced by 75042

12617 Hamlin Inc.
Lake Mills, Wisconsin

12697 Clarostat Mfg. Co.
Dover, New Hampshire

12749 James Electronics
Chicago, Illinois

12856 Micrometals
Sierra Madre, California

12954 Dickson Electronics Corp.
Scottsdale, Arizona

13606 Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839 Replaced by 23732

14099 Semtech Corp.
Newbury Park, California

14193	California Resistor Corp. Santa Monica, California
14298	American Components, Inc. Conshohocken, Pennsylvania
14655	Cornell-Dubilier Electronics Newark, New Jersey
14674	Corning Glass Works Corning, New York
14752	Electro Cube Inc. San Gabriel, California
14869	Replaced by 96853
15636	Elec-Trol Inc. Northridge, California
15801	Fenwal Electronics Inc. Framingham, Massachusetts
15818	Amelco Semiconductor Div. of Teledyne Inc. Mountain View, California
15849	Useco, Inc. Mt. Vernon, New York
15909	Replaced by 17870
16332	Replaced by 28478
16473	Cambridge Scientific Ind. Inc. Cambridge, Maryland
16742	Paramount Plastics Downey, California
16758	Delco Radio Div. of General Motors Kokomo, Indiana
17069	Circuit Structures Lab. Upland, California
17856	Siliconix, Inc. Sunnyvale, California
17870	Daven-Div. of Thomas A. Edison Ind. – McGraw-Edison Co. Manchester, New Hampshire
18083	Deleted
18178	Vactec Inc. Maryland Heights, Missouri
18736	Voltronics Corp. Hanover, New Jersey
19429	Montronics, Inc. Seattle, Washington
19451	Perine Machinery & Supply Co. Seattle, Washington
19701	Electra Mfg. Co. Independence, Kansas
20584	Enochs Mfg. Co. Indianapolis, Indiana
22767	ITT Semiconductors Div. of ITT Palo Alto, California
23732	Tracor Rockville, Maryland
24248	Southco Division of South Chester Corp. Lester, Pennsylvania
24655	General Radio Co. West Concord, Massachusetts
25403	Amperex Electronic Corp. Semiconductor & Receiving Tube Division Slatersville, Rhode Island
28478	Deltrol Controls Corp. Milwaukee, Wisconsin
28480	Hewlett Packard Co. Palo Alto, California
28520	Heyman Mfg. Co. Kenilworth, New Jersey
30323	Illinois Tool Works Inc. Chicago, Illinois
32539	Mura Corporation Great Neck, New York
32767	Griffith Plastic Products Co. Burlingame, California
32879	Advanced Mechanical Comp. Northridge, California
33173	General Electric Co. Tube Dept. Owensboro, Kentucky
37942	Mallory, P. R., & Co., Inc. Indianapolis, Indiana
38315	Honeywell Inc. Precision Meter Div. Manchester, New Hampshire
42498	National Company Melrose, Massachusetts
43543	Nytronics Inc. Transformer Co. Div. Alpha, New Jersey
44655	Ohmite Mfg. Co. Skokie, Illinois
49671	Radio Corp. of America New York, New York
49956	Raytheon Company Lexington, Maine
53021	Sangamo Electric Co. Springfield, Illinois
55026	Simpson Electric Company Chicago, Illinois
56289	Sprague Electric Co. North Adams, Massachusetts
58474	Superior Electric Co. Bristol, Connecticut
60399	Torrington Mfg. Co. Torrington, Connecticut
62460	Deleted
63743	Ward Leonard Electric Co. Mount Vernon, New York
64834	West Mfg. Co. San Francisco, California
65092	Weston Instruments Inc. Newark, New Jersey
66150	Winslow Tele-Tronics Inc. Asbury Park, New Jersey
70563	Amperite Company Union City, New Jersey
70903	Belden Mfg. Co. Chicago, Illinois
71002	Birnbach Radio Co., Inc. New York, New York
71400	Bussmann Mfg. Div. of McGraw-Edison Co. St. Louis, Missouri
71450	CTS Corp. Elkhart, Indiana
71468	ITT Cannon Electric Inc. Los Angeles, California
71482	Clare, C. P. & Co. Chicago, Illinois
71590	Centralab Div. of Glove Union Inc. Milwaukee, Wisconsin
71707	Coto Coil Co., Inc. Providence, Rhode Island
71744	Chicago Miniature Lamp Works Chicago, Illinois
71785	Cinch Mfg. Co. & Howard B. Jones Div. Chicago, Illinois
72005	Driver, Wilber B., Co. Newark, New Jersey
72092	Replaced by 06980
72136	Electro Motive Mfg. Co. Willimantic, Connecticut
72259	Nytronics Inc. Berkeley Heights, New Jersey
72354	Deleted
72619	Dialight Corp. Brooklyn, New York
72653	G. C. Electronics Rockford, Illinois
72665	Replaced by 90303
72794	Dzus Fastener Co., Inc. West Islip, New York
72928	Gudeman Co. Chicago, Illinois
72982	Erie Tech. Products Inc. Erie, Pennsylvania
73138	Beckman Instruments Inc. Helipot Division Fullerton, California
73293	Hughes Aircraft Co. Electron Dynamics Div. Newport Beach, California
73445	Amperex Electronic Corp. Hicksville, New York
73559	Carling Electric Inc. Hartford, Connecticut
73586	Circle F Industries Trenton, New Jersey
73734	Federal Screw Products, Inc. Chicago, Illinois
73743	Fischer Special Mfg. Co. Cincinnati, Ohio
73899	JFD Electronics Co. Brooklyn, New York
73949	Guardian Electric Mfg. Co. Chicago, Illinois
74199	Quam Nichols Co. Chicago, Illinois
74217	Radio Switch Corp. Marlboro, New Jersey
74276	Signalite Inc. Neptune, New Jersey
74306	Piezo Crystal Co. Carlisle, Pennsylvania
74542	Hoyt Elect. Instr. Works Penacook, New Hampshire
74970	Johnson, E. F., Co. Waseca, Minnesota
75042	IRC Inc. Philadelphia, Pennsylvania
75376	Kurz-Kasch, Inc. Dayton, Ohio
75382	Kulka Electric Corp. Mt. Vernon, New York
75915	Littlefuse Inc. Des Plaines, Illinois
76854	Oak Mfg. Co. Crystal Lake, Illinois
77342	Potter & Brumfield Div. of Amer. Machine & Foundry Princeton, Indiana
77969	Rubbercraft Corp. of Calif. LTD Torrance, California
78189	Shakeproof Div. of Illinois Tool Works Elgin, Illinois
78277	Sigma Instruments, Inc. South Braintree, Massachusetts
78488	Stackpole Carbon Co. St. Marys, Pennsylvania
78553	Tinnerman Products Cleveland, Ohio
79136	Waldes Kohinoor Inc. Long Island City, New York
79497	Western Rubber Company Goshen, Indiana
79963	Zierick Mfg. Corp. New Rochelle, New York
80031	Mepco Div. of Sessions Clock Co. Morristown, New Jersey
80145	API Instruments Co. Chesterland, Ohio
80183	Sprague Products North Adams, Massachusetts
80294	Bourns Inc. Riverside, California
80583	Hammarlund Co., Inc. Mars Hill, North Carolina
80640	Stevens, Arnold Inc. Boston, Massachusetts
81073	Grayhill Inc. La Grange, Illinois
81312	Winchester Electronics Div. of Litton Industries Oakville, Connecticut
81439	Therm-O-Disc Inc. Mansfield, Ohio
81483	International Rectifier Corp. El Segundo, California
81590	Korry Mfg. Co. Seattle, Washington
82376	Deleted
82389	Switchcraft Inc. Chicago, Illinois
82415	Price Electric Corp. Frederick, Maryland
82872	Roanwell Corp. New York, New York
82877	Rotron Mfg. Co., Inc. Woodstock, New York
82879	ITT Wire & Cable Div. Pawtucket, Rhode Island
83003	Varo Inc. Garland, Texas
83298	Bendix Corp. Electric Power Division Eatontown, New Jersey
83330	Smith, Herman H., Inc. Brooklyn, New York
83478	Rubbercraft Corp. of America New Haven, Connecticut
83594	Burroughs Corp. Electronic Components Div. Plainfield, New Jersey
83740	Union Carbide Corp. Consumer Products Div. New York, New York
84171	Arco Electronics, Inc. Great Neck, New York
84411	TRW Ogallala, Nebraska

86577	Precision Metal Products Stoneham, Massachusetts
86684	Radio Corp. of America Electronic Components & Devices Harrison, New Jersey
86689	Deleted
87034	Marco-Oak Inc. Anaheim, California
88419	Use 14655
88690	Replaced by 04217
89536	Fluke, John Mfg. Co., Inc. Seattle, Washington
89730	Replaced by 08806
90201	Mallory Capacitor Co. Indianapolis, Indiana
90215	Best Stamp & Mfg. Co. Kansas City, Missouri
90211	Square D Co. Chicago, Illinois
90303	Mallory Battery Co. Tarrytown, New York
91293	Johanson Mfg. Co. Boonton, New Jersey
91407	Replaced by 58474
91637	Dale Electronics Inc. Columbus, Nebraska
91662	Elco Corp. Willow Grove, Pennsylvania
91737	Gremar Mfg. Co., Inc. Wakefield, Massachusetts
91802	Industrial Devices, Inc. Edgewater, New Jersey
91836	King's Electronics Tuckahoe, New York
91929	Honeywell Inc. Micro Switch Div. Freeport, Illinois
91934	Miller Electric Co., Inc. Pawtucket, Rhode Island
93332	Sylvania Electric Products Semiconductor Products Div. Woburn, Massachusetts
94145	Replaced by 49956
94154	Tung-Sol Div. of Wagner Electric Corp. Newark, New Jersey
95146	Alco Electronics Products Inc. Lawrence, Massachusetts
95263	Leecraft Mfg. Co. Long Island City, New Jersey
95264	Replaced by 98278
95275	Vitramon Inc. Bridgeport, Connecticut
95303	Radio Corp. of America Solid State & Receiving Tube Div. Cincinnati, Ohio
95354	Methode Mfg. Corp. Rolling Meadows, Illinois
95712	Dage Electric Co., Inc. Franklin, Indiana
95987	Weckesser Co., Inc. Chicago, Illinois
96733	San Fernando Electric Mfg. Co. San Fernando, California
96853	Rustrak Instrument Co. Manchester, New Hampshire
96881	Thomson Industries, Inc. Manhasset, New York
97540	Master Mobile Mounts Div. of Whitehall Electronics Corp. Los Angeles, California
97913	Industrial Electronic Hdware Corp. New York, New York
97945	White, S. S. Co. Plastics Div. New York, New York
97966	Replaced by 11358
98094	Replaced by 49956
98278	Microdot Inc. Pasadena, California
98291	Scalectro Corp. Conhex Div. Mamaroneck, New York
98388	Accurate Rubber & Plastics Culver City, California
98743	Replaced by 12749
98925	Deleted
99120	Plastic Capacitors Inc. Chicago, Illinois
99217	Southern Electronics Corp. Burbank, California
99515	Marshall Industries Capacitor Div. Monrovia, California

Appendix B

List of Abbreviations

A,amp	ampere
ampl	amplifier
ac	alternating current
assy	assembly
BCD	binary coded decimal
cap	capacitor
car	carbon
cm	centimeter
C	centigrade
cer	ceramic
cw	clockwise
CMRR	common mode rejection ratio
comp	composition
CCW	counterclockwise
conn	connector
CRT	cathode ray tube
cps	cycles per second
db	decibel
dvm	digital voltmeter
dc	direct current
dpdt	double-pole, double-throw
dpst	double-pole, single-throw
elect	electrolytic
ext	external
f	fahrenheit
F	farad
FET	field effect transistor
flm	film
Ge	germanium
g	giga or 10^9
gnd	ground
gmv	guaranteed minimum value
grd	guard
h	henry
Hz	hertz
hf	high frequency
IC	integrated circuit
if	intermediate frequency
int	internal
kc	kilocycle
k	kilo (10^3)
lf	low frequency
mc	megacycle
M	meg or mega (10^6)
met	metal
MOS	metal oxide silicon
μ	micro or 10^{-6}
m	milli or 10^{-3}
mm	millimeter
n	nano or 10^{-9}
neg	negative
Ω	ohm
osc	oscilloscope
ppm	parts per million
piv	peak inverse voltage
p-p	peak to peak
p	pico or 10^{-12}
plstc	plastic
$\pm$	plus or minus
pos	positive
pps	pulses per second
PCB	printed circuit board
QTY	quantity
rf	radio frequency
rfi	radio frequency interference
REC	recommended
REF	reference
RH	relative humidity
res	resistor
rms	root mean square
rtry	rotary
sec	second
sect	section
S/N	serial number
Si	silicon
scr	silicon controlled rectifier
spdt	single-pole, double-throw
spst	single-pole, single-throw
sw	switch
Ta	tantalum
TC	temperature coefficient
t	tera or 10^{12}
xfmr	transformer
tstr	transistor
tvm	transistor voltmeter
uhf	ultra high frequency
vtvm	vacuum tube voltmeter
var	variable
vhf	very high frequency
vlf	very low frequency
V	volt
VCO	voltage controlled oscillator
w	watt
ww	wire wound

Appendix C

Sales Representatives

ALABAMA
HUNTSVILLE
BSC Associates, Inc.
3322 S. Memorial Parkway
P.O. Box 1273
Tel. (205) 881-6220
Zip 35807

ALASKA
SEATTLE
Showalter-Judd, Inc.
1806 S. Bush Place
Seattle, Washington 98144
Tel. (206) 324-7911

ARIZONA
PHOENIX
Barnhill Associates
537 E. Osborn Road, Suite 4
Tel. (602) 263-1250
Zip 85012

CALIFORNIA
LOS ANGELES
Instrument Specialists, Inc.
1109 S. Central Ave.
Glendale, California 91204
Tel (213) 245-9404

SANTA CLARA
Instrument Specialists, Inc.
2359 De La Cruz Blvd.
Tel. (408) 244-1505
Zip 95050

SAN DIEGO
Instrument Specialists, Inc.
1909 State St.
Tel. (714) 232-2017
Zip 92101

COLORADO
DENVER
Barnhill Associates
1170 S. Sheridan Blvd.
Tel. (303) 934-5505
Zip 80226

CONNECTICUT
HARTFORD
Instrument Representatives, Inc.
P. O. Box 165
Glastonbury, Connecticut 06033
Tel (203) 633-0777

FLORIDA
ORLANDO
BCS Associates, Inc.
940 N. Fern Creek Ave.
P.O. Box 6578
Tel. (305) 843-1510
Zip 32803

GEORGIA
ATLANTA
BCS Associates, Inc.
1230 Briar Hill Dr.
Tel. (404) 874-9925
Zip 30306

HAWAII
HONOLULU
Industrial Electronics, Inc.
646 Queen Street
P.O. Box 135
Tel. (808) 533-6095
Zip 96817

ILLINOIS
CHICAGO
Cozzens & Cudahy, Inc.
9501 W. Devon Ave.
Rosemont, Illinois 60018
Tel. (312) 825-1144

INDIANA
INDIANAPOLIS
Cozzens & Cudahy, Inc.
Port O'Call Executive Ctr.
21 Beachway Drive
Tel. (317) 244-2456
Zip 46234

MARYLAND
BALTIMORE
Electronic Marketing Assoc. Inc.
11501 Huff Court
Kensington, Maryland 20795
Tel. (301) 881-5300, 744-7700

MASSACHUSETTS
BOSTON
Instrument Representatives, Inc.
1046 Massachusetts Avenue
Arlington, Massachusetts 02174
Tel. (617) 646-1034

MICHIGAN
DETROIT
WKM Associates, Inc.
1474 East Outer Dr.
Tel. (313) 892-2500
Zip 48234

MINNESOTA
MINNEAPOLIS
Cozzens & Cudahy, Inc.
7450 France Ave. So.
Tel. (612) 920-1022
Zip 55435

MISSOURI
ST. LOUIS
Cozzens & Cudahy, Inc.
P. O. Box 10013
Lambert Field - Zip 63145
Tel. (314) 423-1234

NEW JERSEY
NEWARK
SBM Representatives
1519 Stuyvesant Avenue
Union, New Jersey 07083
Tel. (201) 687-8737

NEW MEXICO
ALBUQUERQUE
Barnhill Associates
1410—D Wyoming N.E.
Tel. (505) 299-7658
Zip 87110

NEW YORK
NEW YORK
SBM Representatives
28 Hobby Street
Pleasantville, N.Y. 10570
Tel. (914) 769-1811

ROCHESTER
SBM Representatives
4515 Culver Rd.
Tel. (716) 226-1400
Zip 14622

NORTH CAROLINA
GREENSBORO
BCS Associates, Inc.
1039 E. Wendover Ave.
P.O. Box 6426
Tel. (919) 273-1918
Zip 27405

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CLEVELAND
WKM Associates, Inc.
16141 Puritas Ave.
Tel. (216) 267-0445
Zip 44135

DAYTON
WKM Associates, Inc.
6073 Far Hills Ave.
Tel. (513) 434-7500
Zip 45429

OREGON
PORTLAND
Showalter-Judd, Inc.
1445 N. E. Arrington
Hillsboro, Oregon 97123
Tel. (503) 648-6372

PENNSYLVANIA
PHILADELPHIA
Electronic Marketing Assoc.
210 Goddard Blvd.—Suite 100
King of Prussia, Pennsylvania
Tel (215) 248-5050
Zip 19406

PITTSBURGH
WKM Associates, Inc.
90 Clairton Blvd.
Tel. (412) 892-2953
Zip 15236

TEXAS
DALLAS
Barnhill Associates
Suite 220
312 N. Central Express Wy.
Richardson, Texas 75080
Tel. (214) 231-2573

HOUSTON
Barnhill Associates
Suite 332
3810 Westheimer
Tel. (713) 621-0040
Zip 77027

EASTERN VIRGINIA
WILLIAMSBURG
BCS Associates, Inc.
107 Rich Neck Road
Tel. (703) 229-5108
Zip 23185

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SEATTLE
Showalter-Judd, Inc.
1806 S. Bush Place
Seattle, Washington 98144
Tel. (206) 324-7911

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VANCOUVER
Allan Crawford Associates, Ltd.
1820 Pandora St.
Tel. (604) 253-7136

ONTARIO
MALTON
Allan Crawford Associates, Ltd.
6427 Northam Drive.
Tel. (416) 678-1500

OTTAWA, 3
Allan Crawford Associates, Ltd.
376 Churchill Ave. — Suite 106
Tel. (613) 725-3354

QUEBEC
LONGUEUIL
Allan Crawford Associates, Ltd.
157 (rue) St. Charles Street W.
Tel. (514) 670-1212

INTERNATIONAL REPRESENTATIVES

ARGENTINA

Coasin S.A.
Virrey del Pino 4071
Buenos Aires, Argentina

AUSTRALIA

Elmeasco Instruments
7 Chard Road
P.O. Box 334
Brookvale, N.S.W. Australia 2100

AUSTRIA

Kontron GMBH & Co., Kg.
Lederergasse 16
1080 Wien
Austria

BELGIUM

C. N. Rood S/A
37, Place de Jamblinne de Meux
B-1040 Brussels, Belgium

BRAZIL

AMBRIEX S.A.
Av. Graca Aranha
226—6º And.
Rio De Janeiro, Brazil

AMBRIEX S.A.
Av. Pacaembu, 811
Sao Paulo, Brazil

CHILE

Coasin Chile Ltd.
Casilla 14588
Correo 15
Santiago, Chile

COLOMBIA

Marones Ltda.
Apartado Aereo 90687
Bogota 8, Colombia

DENMARK

Tage Olsen A/S
1, Ronnegade
Copenhagen 0, Denmark

FINLAND

Oy Findip AB
Postbox 52025
Helsinki 52, Finland

FRANCE

Radio Equipment Antares
9, Rue Ernest Cognacq
92 Levallois — Perret
France

GREECE

Marios Dalleggio Representations
2 Alopekis Street
Athens 19 Greece

HONG KONG

Gilman & Co. Ltd.
P.O. Box 56
Hong Kong

INDIA

Hinditron Services Pvt. Ltd.
69/A Nepean Sea Road
Bombay 6, India

IRAN

Berkeh Company Ltd.
20 Salm Road, Roosevelt Ave.
Tehran, Iran

ISRAEL

R.D.T. Electronics Eng'r. Ltd.
P.O. Box 21082
Tel Aviv, Israel

ITALY

Elettronucleonica S.P.A.
7, P.zza De Angeli
20146 Milano, Italy

JAPAN

Toyo Trading Co., Ltd.
P.O. Box 5014
International Tokyo
Japan

2-38 Junkeicho-dori
Minami-ku, Osaka, Japan

KOREA

M-C International
I.P.O. Box 1355
Seoul, Korea

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P.O. Box 1197
Kota Kinabalu
East Malaysia

P.O. Box 91
Pataling Jaya
West Malaysia

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Mexitek, S.A.
Eugenia 408
Departments 1 y 5
Mexico 12, D.F.

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C.N. Rood N.V.
Post Office Box 4542
Rijswijk (Z.H.) 2100
The Netherlands

Fluke (Nederland) N.V.
Post Office Box 5053
Industrieterrein Noord
Tilburg, The Netherlands

NEW ZEALAND

Elmeasco Instruments Pty. Ltd.
Suite 1, 33 Queens Road
Melbourne, Vic. 3004
Australia

NIGERIA

Deemtee Electrotechnics Ltd.
P.O. Box 3073
Lagos, Nigeria

NORWAY

Morgenstierne & Co. A/S
P.B. 6688 Rodelokka
Oslo 6, Norway

PAKISTAN

Pak International Operations
P.O. Box 5323
Karachi, Pakistan

PORTUGAL

Equipamentos De Laboratorio, Ltda.
P.O. Box 1100
Lisbon, Portugal

SINGAPORE

O'Connor's (Pte) Ltd.
Maybank House 124-126
Robinson Road
Singapore 1, Singapore

SOUTH AFRICA

K. Baker (Pty.) Ltd.
P.O. Box 1257
Johannesburg, So. Africa

P.O. Box 3641
Cape Town, So. Africa

P.O. Box 2143
Durban, So. Africa

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Rema Leo Haag, S.A.
General Sanjurjo 18
Madrid 3, Spain

SWEDEN

Erik Ferner AB
Box 56
Snormakarvagen 35
161.26 Stockholm-Bromma
Sweden

SWITZERLAND

Kontron Electronic A.G.
Hardstrasse 235
P.O. Box 193
8031 Zurich
Switzerland

TAIWAN-REPUBLIC OF CHINA

Heighten Trading Co., Ltd.
P.O. 1408
Taipei, Taiwan, 104

THAILAND

G.Simon Radio Ltd.
30 Patpong Avenue
Suriwong
Bangkok, Thailand

THE UNITED KINGDOM

Fluke International Corp.
Garnett Close
Watford, WD2 4TT
England

URUGUAY

Coasin Uruguaya S.A.
Cerrito 617 - 4º Piso
Montevideo, Uruguay

VENEZUELA

Coasin C.A.
APDO, Postal 50939
Sabana Grande No. 1
Caracas, Venezuela

In Europe, contact FLUKE NEDERLAND, N.V., POST OFFICE BOX 5053, INDUSTRIETERREIN NOORD, TILBURG, THE NETHERLANDS

FLUKE REGIONAL SERVICE CENTER; THE NETHERLANDS

FLUKE (NEDERLAND) N.V.
P. O. BOX 5053
TILBURG, THE NETHERLANDS

FLUKE REGIONAL SERVICE CENTER, UNITED KINGDOM

FLUKE INTERNATIONAL CORP.
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WATFORD, WD2 4TT
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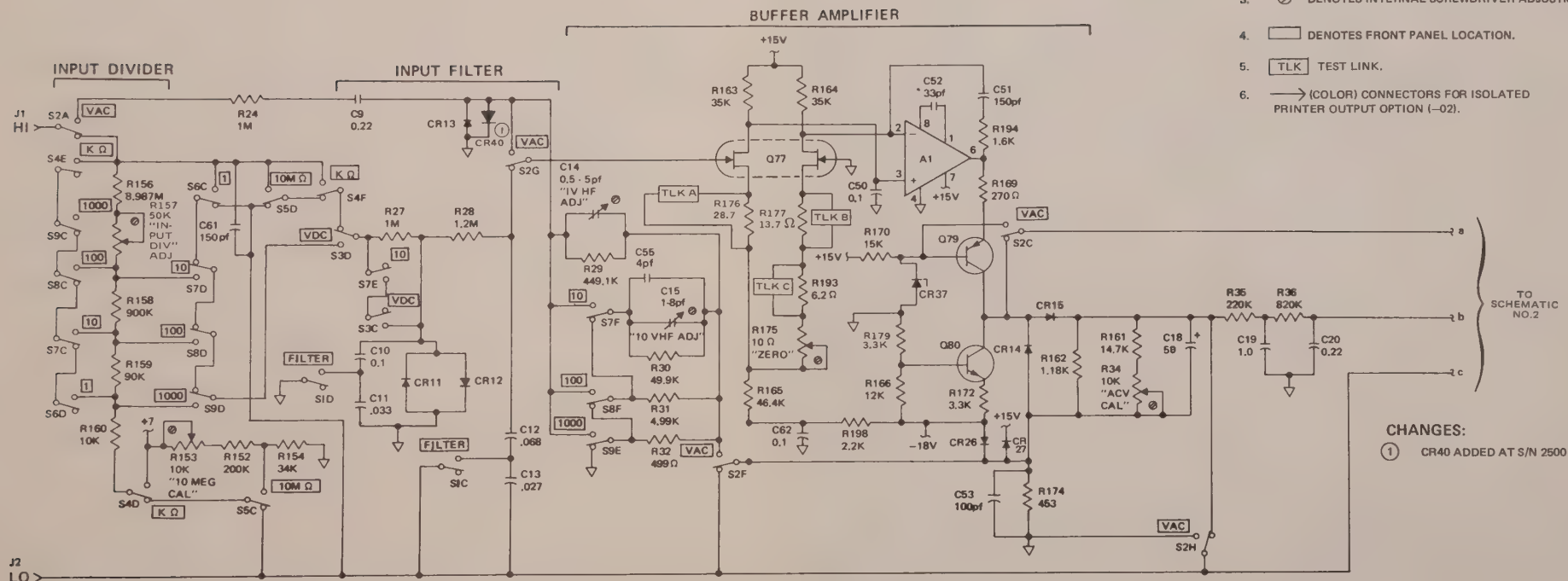
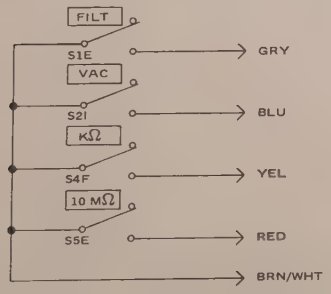
BUFFER





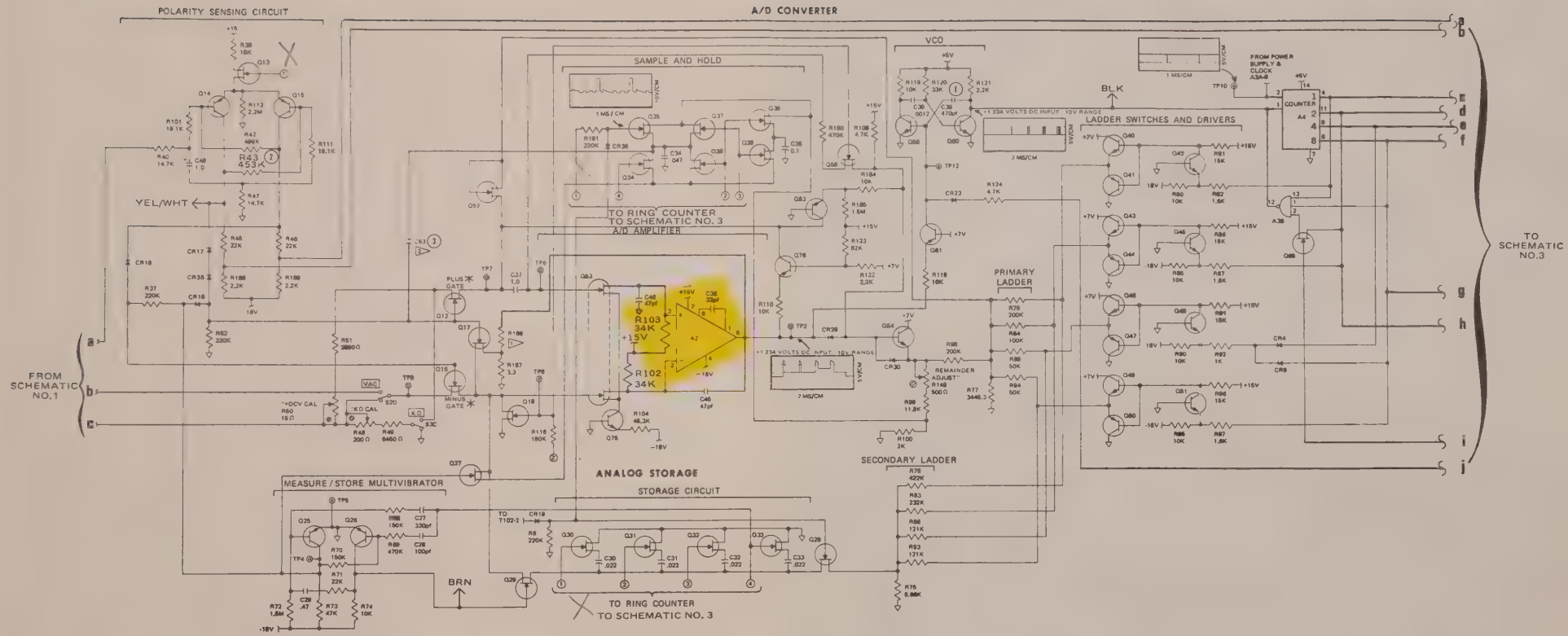
NOTES;

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ALL SWITCHES SHOWN IN OFF POSITION.
3. ⊘ DENOTES INTERNAL SCREWDRIVER ADJUSTMENT.
4. ▭ DENOTES FRONT PANEL LOCATION.
5. TLK TEST LINK.
6. ⟶ (COLOR) CONNECTORS FOR ISOLATED PRINTER OUTPUT OPTION (–02).

CHANGES:

(1) CR40 ADDED AT S/N 2500 AND ON.

FUNCTIONAL SCHEMATIC DIAGRAM	
MODEL 8100A DIGITAL MULTIMETER SCHEMATIC NO. 1	
SER. NO. 123 THRU 3409 AND 3420 THRU 4097	REV d
FLUKE JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133	



NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ALL SWITCHES SHOWN IN OFF POSITION.
3. ⊘ DENOTES INTERNAL SCREWDRIVER ADJUSTMENT.
4. ▭ DENOTES FRONT PANEL LOCATION.
5. [1] R186 SELECTED IN FINAL CALIBRATION.
6. [2] C63 SELECTED COMPONENT; NOT PRESENT ON SOME UNITS.
7. ✳ PLUS GATE ON WITH POSITIVE INPUT; MINUS GATE ON WITH NEGATIVE INPUT.
8. ⟶ (COLOR) CONNECTORS FOR ISOLATED PRINTER OUTPUT OPTION (—02).

CHANGES:

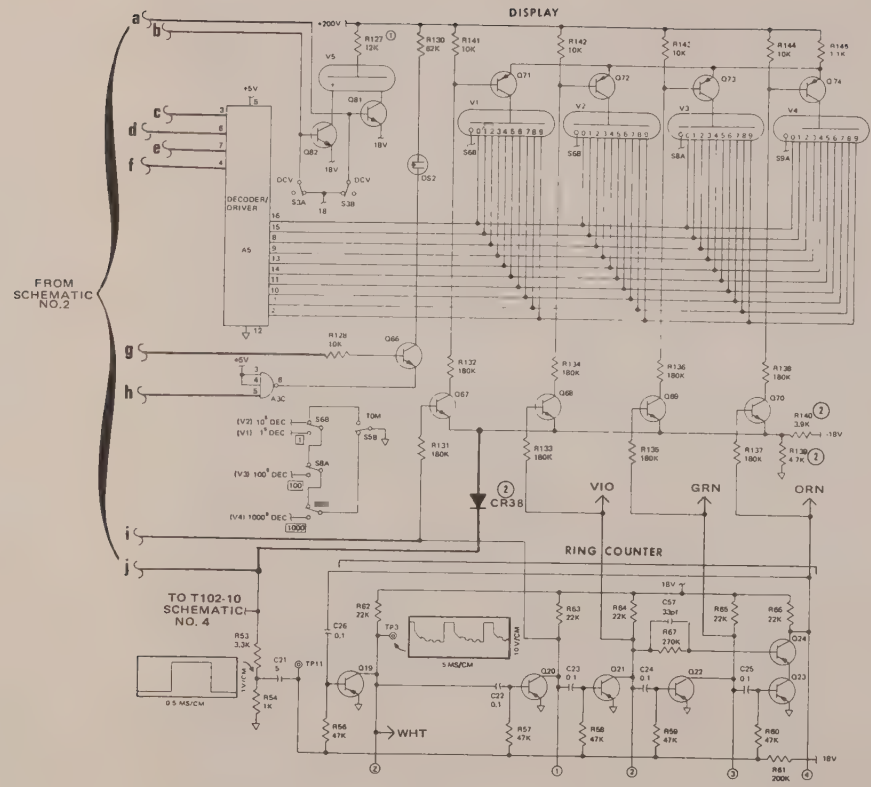
(1) C39 IS 220 pf IN SERIAL NUMBERS 124-131, 134, 135, 137, 139, 141, 142, 146, 147, 149-151, 157-159, 161-163, 165, 167-170.

(2) FOR S/N 123 THRU 2844: R43 WAS 499K.

(3) FOR S/N 2000 AND ON: C63 DELETED.

FUNCTIONAL SCHEMATIC DIAGRAM	
MODEL 8100A DIGITAL MULTIMETER SCHEMATIC NO. 2	
SER. NO. 123 THRU 3409 AND 3420 THRU 4097	REV. d

FLUKE JOHN FLUKE MFG. CO., INC.
P.O. Box 7428 Seattle, Washington 98133



CHANGES:

(1) R127 CHANGED FROM 22K to 12K AT APPROXIMATELY S/N 400.

(2) For S/N 2000 and on:
CR38 added
R139, R140 deleted

NOTES:

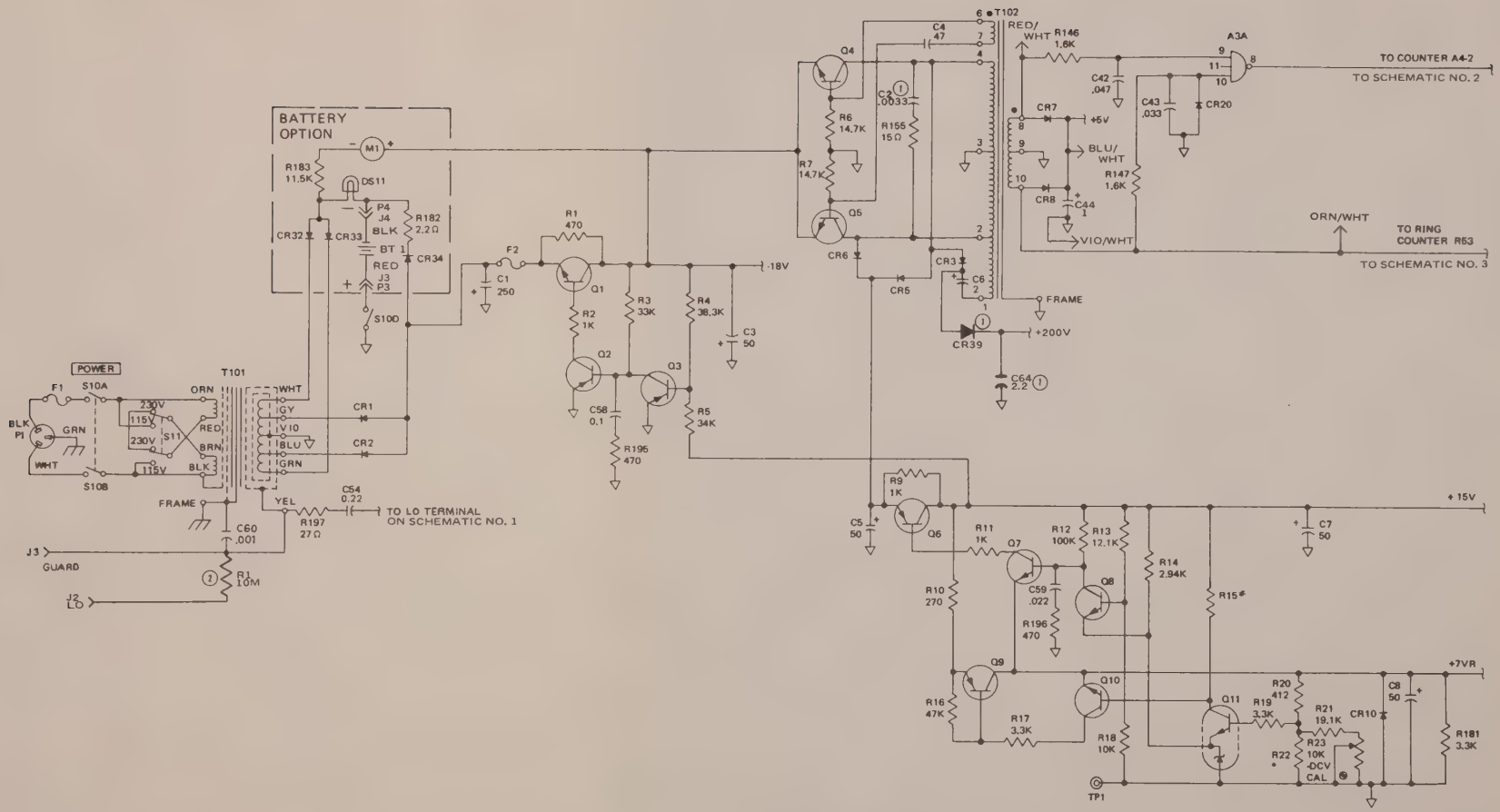
1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ALL SWITCHES SHOWN IN OFF POSITION.
3. READOUT TUBE PIN LAYOUT:

	1	0	0
	2	0	9
	3	0	8
RHD	4	0	7 LHD
	5	0	6
	6	0	5

BOTTOM VIEW

4. ▭ DENOTES FRONT PANEL LOCATION.
5. ⟶ (COLOR) CONNECTORS FOR ISOLATED PRINTER OUTPUT OPTION(—02)

FUNCTIONAL SCHEMATIC DIAGRAM	
MODEL 8100A DIGITAL MULTIMETER SCHEMATIC NO. 3	
SER. NO. 123 thru 3409 AND 3420 THRU 4097	REV d
FLUKE JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133	



NOTES:

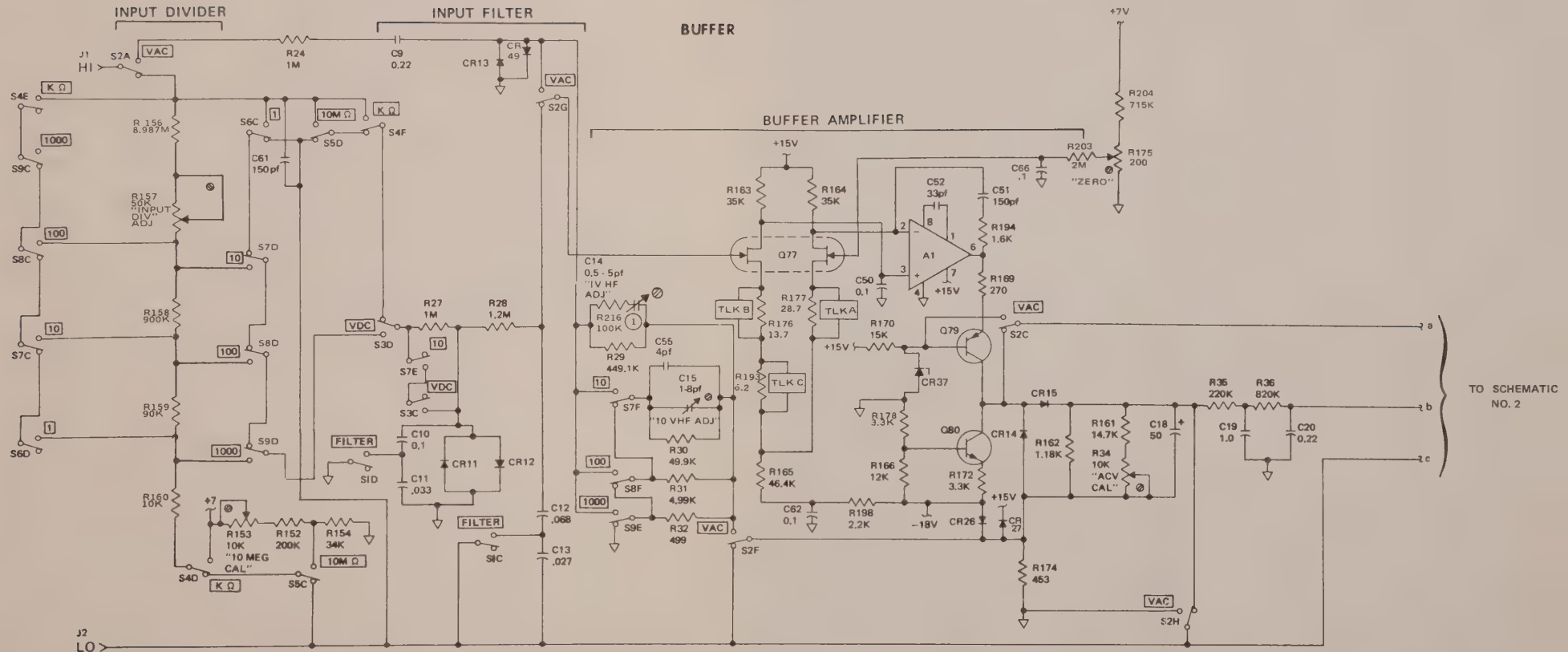
1. *RESISTOR VALUE SELECTED AT TEST OF Q11.
2. ⟶ (COLOR) CONNECTORS FOR ISOLATED PRINTER OUTPUT (—02)

CHANGES:

(1.) FOR S/N 123 THRU 1999: C2 WAS 0.0012uf. CR39 AND C64 NOT INSTALLED.

(2.) FOR S/N 4260 AND ON: R_1, 10M, ADDED.

FUNCTIONAL SCHEMATIC DIAGRAM	
MODEL 8100A DIGITAL MULTIMETER SCHEMATIC NO. 4	
SER. NO. 123 THRU 3409 AND 3420 THRU 4097	REV. d
FLUKE JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133	



NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ALL SWITCHES SHOWN IN OFF POSITION.
3. ⊘ DENOTES INTERNAL SCREWDRIVER ADJUSTMENT.
4. ▭ DENOTES FRONT PANEL LOCATION.
5. → (COLOR) CONNECTORS FOR ISOLATED PRINTER OUTPUT OPTION (–02).

CHANGES:

① R216 ADDED S/N 5050 AND ON

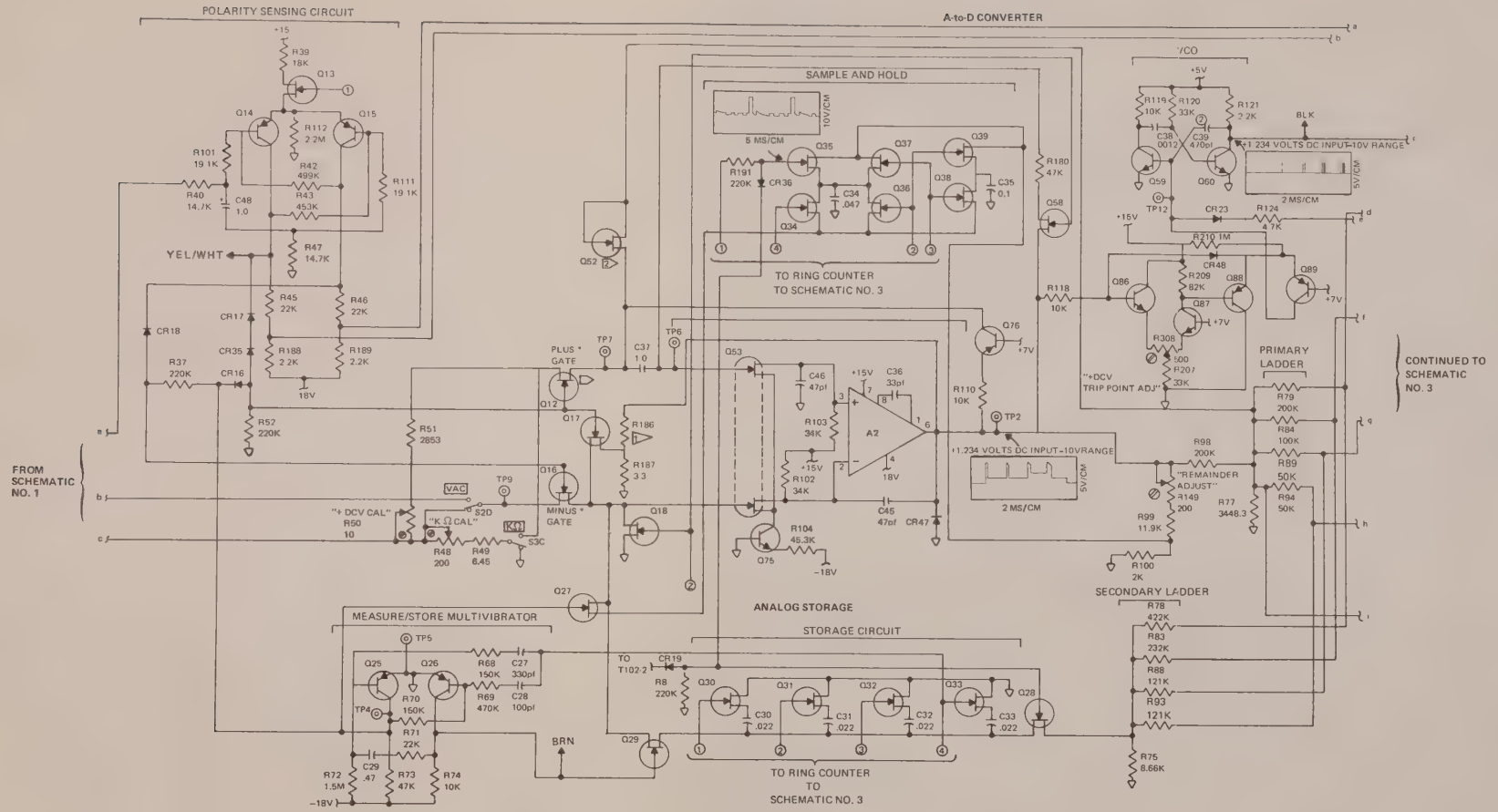
FUNCTIONAL SCHEMATIC DIAGRAM

MODEL 8100A
DIGITAL MULTIMETER

SCHEMATIC NO. 1

SER. NO. 3410 THRU 3419 AND 4098 AND ON | REV C

FLUKE JOHN FLUKE MFG. CO., INC.
P.O. Box 7428 Seattle, Washington 98133



NOTES:

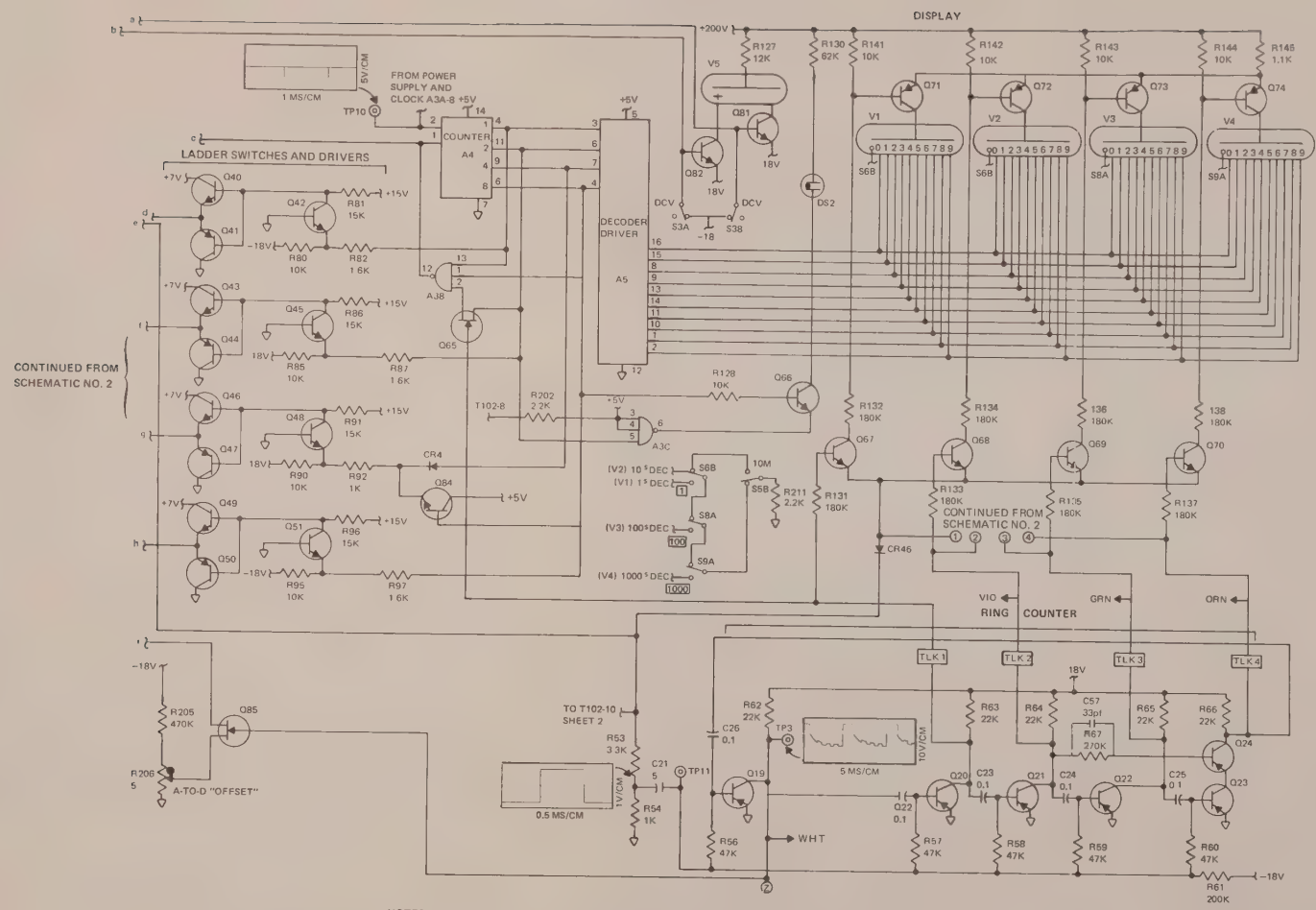
1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ALL SWITCHES SHOWN IN OFF POSITION.
3. ⊘ DENOTES INTERNAL SCREWDRIVER ADJUSTMENT.
4. ▭ DENOTES FRONT PANEL LOCATION.
5. TLK TEST LINK.
6. 1 R186 SELECTED IN FINAL CALIBRATION.
7. (COLOR) CONNECTORS FOR ISOLATED PRINTER OUTPUT OPTION (–02).
8. READOUT TUBE IN PIN LAYOUT:

	1°	°0
	2°	°9
	3°	°A
	4°	°8
RHD°	5°	°7 °LHD
	6°	°A

BOTTOM VIEW

9. °PLUS GATE ON WITH POSITIVE INPUT; MINUS GATE ON WITH NEGATIVE INPUT.
10. 2 MATCHED FET PAIR.

FUNCTIONAL SCHEMATIC DIAGRAM	
MODEL 8100A DIGITAL MULTIMETER	
SCHEMATIC NO. 2	
SER. NO. 3410 THRU 3419 AND 4098 AND ON	REV –
FLUKE JOHN FLUKE MFG CO., INC. P O Box 7428 Seattle Washington 98133	



NOTES:

1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

2. ALL SWITCHES SHOWN IN OFF POSITION.

3. ⊘ DENOTES INTERNAL SCREWDRIVER ADJUSTMENT.

4. ▭ DENOTES FRONT PANEL LOCATION.

5. TLK TEST LINK

6. 1 R186 SELECTED IN FINAL CALIBRATION.

7. → (COLOR) CONNECTORS FOR ISOLATED PRINTER OUTPUT OPTION (–02).

8. READOUT TUBE IN PIN LAYOUT:

	1°	°0	
	2°	°9	
	3°	°A	
RHD°	4°	°8	°LHD
	5°	°7	
	6°	°A	

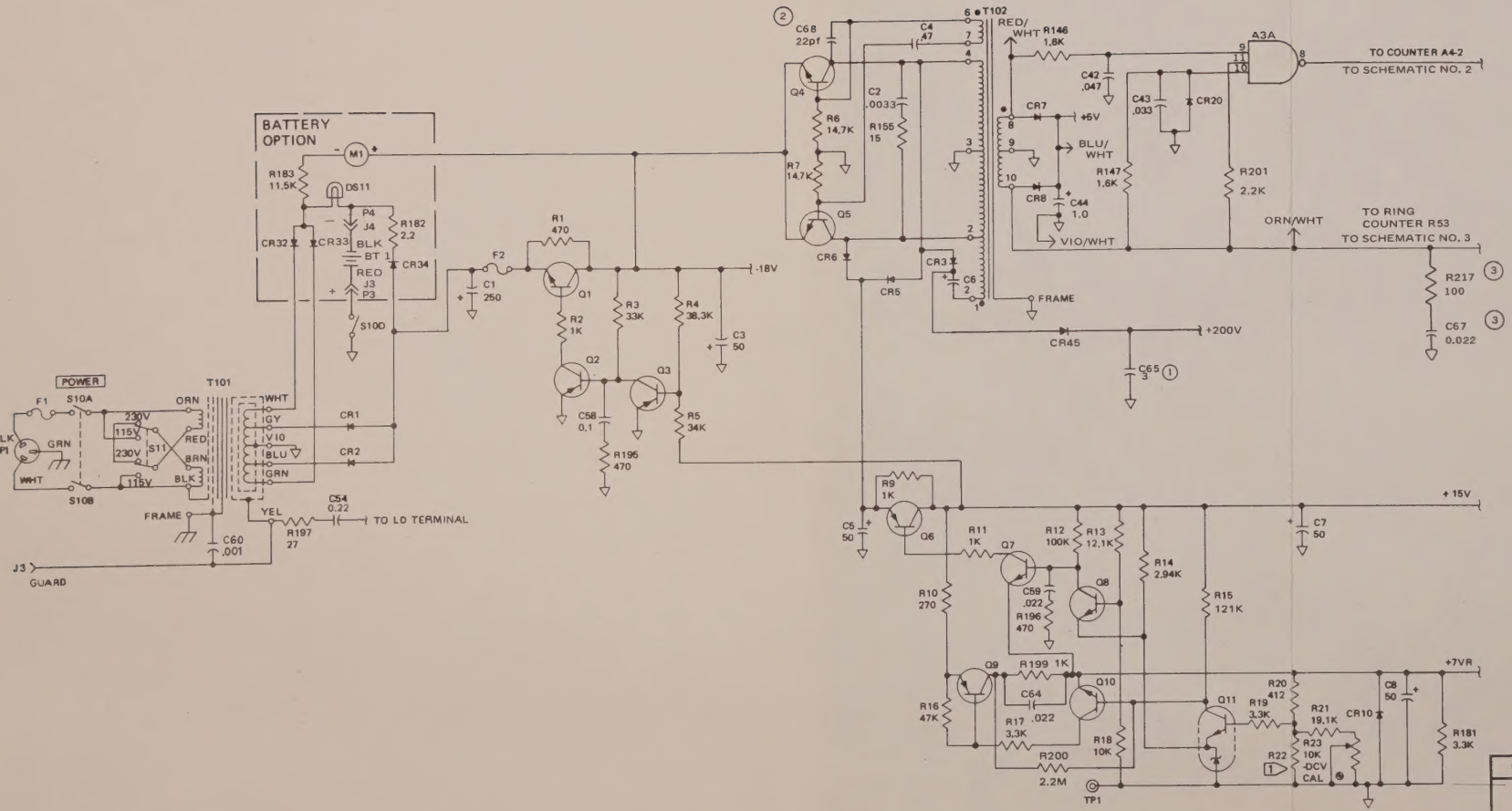
BOTTOM VIEW

9. °PLUS GATE ON WITH POSITIVE INPUT; MINUS GATE ON WITH NEGATIVE INPUT.

FUNCTIONAL SCHEMATIC DIAGRAM	
MODEL 8100A	
DIGITAL MULTIMETER	
SCHEMATIC NO. 3	
SER. NO. 3410 THRU 3419 AND 4098 AND ON	REV –
FLUKE	JOHN FLUKE MFG CO., INC.

NOTES :

1. (1) VALUE SELECTED AT TEST OF Q11



CHANGES:

(1) FOR S/N 3410 THRU 3419, 4098 THRU 4365, & 4429 THRU 4477: C65 WAS 4uf.

(2) C68 ADDED S/N 5050 AND ON.

(3) R217 AND C67 ADDED S/N 5018 AND ON.

(4) → (COLOR) CONNECTORS FOR ISOLATED PRINTER OUTPUT OPTION (-02).

FUNCTIONAL SCHEMATIC DIAGRAM

MODEL 8100A
DIGITAL MULTIMETER

SCHEMATIC NO. 4

SER. NO. 3410 THRU 3419 AND 4098 AND ON

REV. -

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